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CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

VOL. XXII. 1927.

TWENTY-SECOND YEAR OF PUBLICATION

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CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XXII. No. 1. LONDON. JANUARY, 1927.

CONCRETE IN 1926.

In our last New Year Number we made a special feature of illustrations and descriptions of a large number of reinforced concrete structures, and this was so well received that this year we are repeating the feature in the hope that the number and variety of these illustrations will impress those about to embark on constructional work with the extent to which reinforced concrete is now being used, particularly by industrial undertakings and such concerns as gas, water, electricity, dock and harbour, and other authorities. Within the scope of a journal we can only hope to illustrate a fraction of the vast amount of reinforced concrete work now going on, but these photographs, together with the long lists of works in hand by the principal firms, should be sufficient to convince the most conservative that reinforced concrete is not a new material but one that has proved its value as a structural material, and one that is being adopted as the most suitable and economical material for practically every type of constructional work. Many notable reinforced concrete structures have been in progress or completed during the past year, such as the new building for Carreras, which will be the largest reinforced-concrete factory in London and on which a serious attempt will be made to carry out a colour scheme with the use of pre-cast elevations; the new Border Bridge at Berwick which, with a total length of 1,405 feet, and arches up to 360 ft., is the largest reinforced-concrete bridge yet undertaken in this country; the Lea Valley Viaduct, which has received unanimous commendations from the architectural profession on account of its artistic treatment; and many others. The use of rapid-hardening Portland cement to expedite construction has met with great success, as may be seen from the fact that, to cite one instance only, a four-story factory at Wembley covering 17,000 superficial feet was completed within six months.

In wishing our readers and the concrete industry a Prosperous New Year we have no doubt whatever of the enormous scope for the extended use of the material in which we are interested, and which, as this number shows, has already found its place amongst the principal building materials within a short period of thirty years or so.

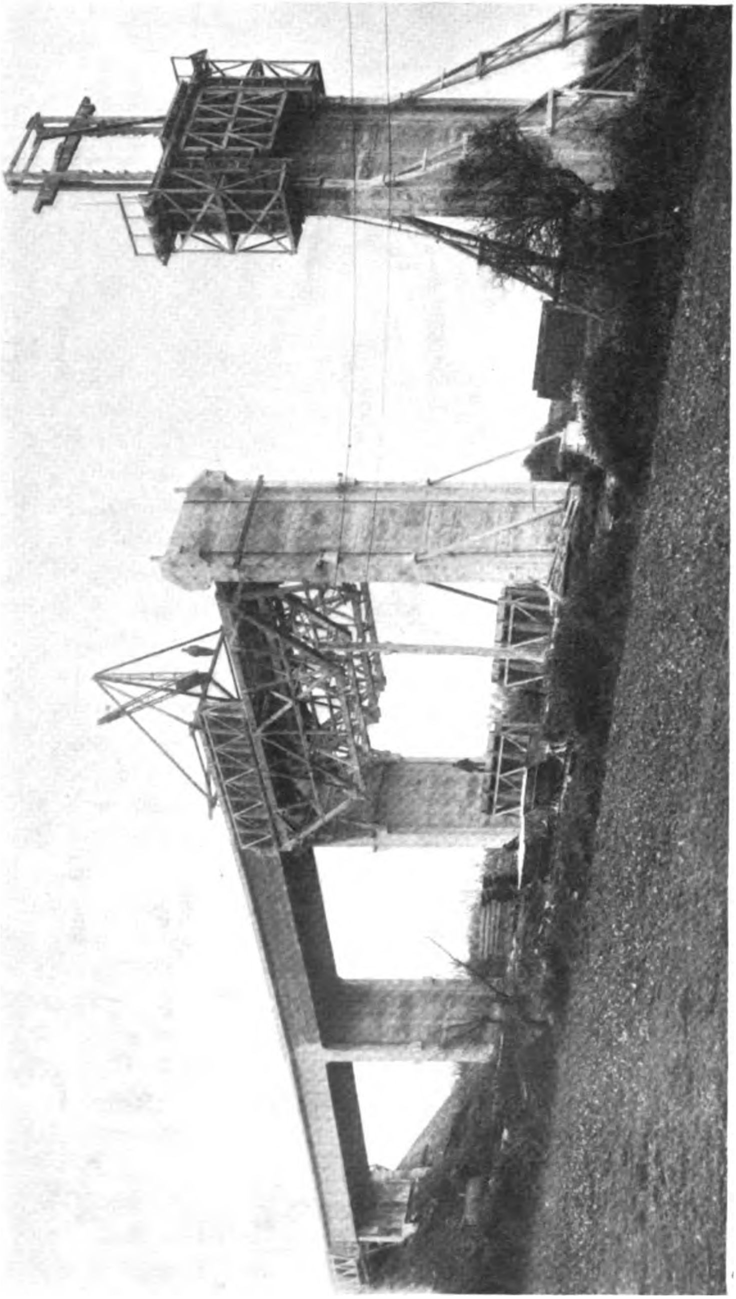


Fig. 13.—Southern Approach Viaduct under Construction. (*See p.* 3.)

Reinforced Concrete Bridge at Brest.

ARCHES OF 600 FT. SPAN.

BY LESLIE TURNER, B.Sc., A.M.Inst.C.E.

(Concluded.)

Anchors.

ANOTHER novel feature is the use of reinforced-concrete anchors. They take the form of a cone the bottom half of which has been turned up at the equivalent angle as shown in *Fig.* 12, which is a section through a diameter. They are of thin section (light enough to float) and converge at their apexes to a bollard-head at their centre. One of these is clearly shown on *Fig.* 14 to the top right-hand quadrant of the large circular coffer dam. A bung-hole is left at the bottom and temporarily filled. After casting and maturing on the shore they are launched and towed out to a suitable point up or down stream. The bung is then pushed out by means of a rod from a boat and the anchor sinks to the river bed, where if necessary it can be loaded. A hawser made fast to the head is led to a buoy, which with others are required for manoeuvring the caisson described later.

The Approaches.

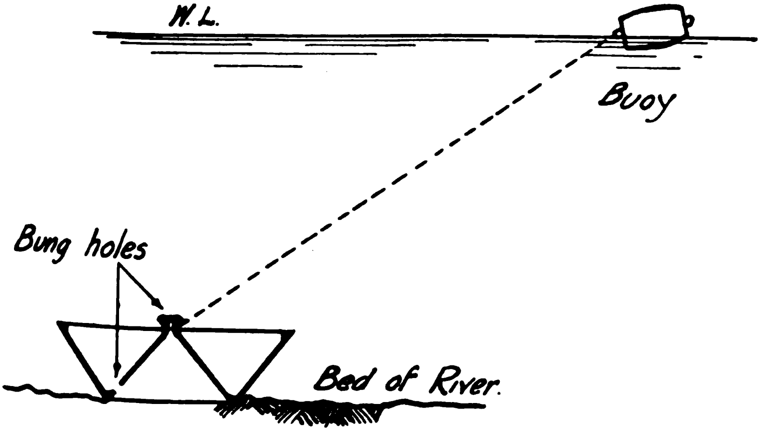
Coming now to the bridge proper, we have first the approaches. The south one is nearing completion and is illustrated in *Fig.* 13, which is a photograph taken during construction. As will be seen, it is a viaduct supported on piers, I-shape in plan, at about 60-ft. centres, varying in height up to 135 ft. They are cast *in situ* from the mould within the climbing cradle, which is hoisted from time to time on the concrete already poured and set. It will be observed that inverted corbels are left at intervals to prop the pier until the decking firmly connects it to its neighbour.

The shuttering for the deck beams and slab and parapet is supported by four timber trusses slung or supported from corbels near the top of the piers. The formwork is sectional, but of timber. In this portion of the work, and generally for the permanent work above high-water level, ordinary Portland cement is used for the concrete. The proportions used are 2·86 parts of coarse aggregate, 2 parts of mixed sand and stone dust, to 1 part of Portland cement.

The north approach will be of similar construction.

Abutments.

Here again the southern side is nearest completion, and is clearly illustrated in



ANCHORS Fig. 12

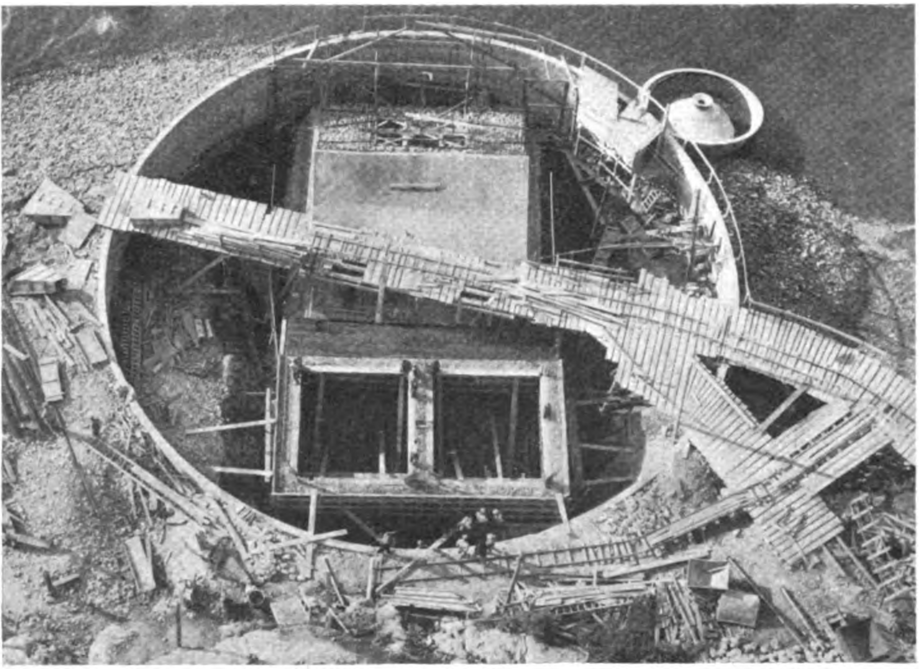


Fig. 14.—Southern Abutment: View from Top of Mast.

Fig. 14 photographed from the top of the south mast. The ring, inside which the abutment and springing have been constructed, is merely temporary and serves as a coffer-dam. It is 92 ft. in diameter, 12 in. thick, built *in situ* during low tides of Portland cement concrete lightly reinforced. At its base it rests on firm rock and in places descends below low-water level and so required diving work in the early stages of its construction. The rim, however, is about 6 in. above highest water level, so that the work within is maintained practically dry and can be carried on continuously irrespective of tides. The greatest depth of the cylindrical wall is about 35 ft., of which 5 ft. is permanently submerged. It will here be noticed that the tidal range to be dealt with is in the neighbourhood of 30 ft.

The foundations for the hollow piers at the abutments are plainly visible, also the back of the springing itself in *Fig.* 15, taken from lower down.

A front view of the latter is given in *Fig.* 16, showing the lap reinforcement to the arch ribs projecting from the mass of cyclopean masonry or concrete of which the block is composed. The boulders used here are again selected pieces from the quarry and occupy about 30 per cent. of the mass.

As previously mentioned, all foundations, including abutments, are taken down to firm rock, and the abutments are solid up to the springing of the arches, where the latter become hollow rectangular tubes. A similar procedure is being adopted on the north bank, where the partially completed circular coffer-dam will be seen in *Fig.* 8 a few feet above water level. As already mentioned, they are temporary and will be broken up and cleared away in due course.

Piers.

The boldest feature of all the work so far is the making, launching, and the ingenious employment of a caisson, or diving bell entirely of reinforced concrete, weighing in all some 900 tons. *Fig.* 17 gives an idea of its size when compared with the men on the foreshore.

It was cast on the south bank, built up on three sand boxes (themselves reinforced concrete cylinders filled with sand)

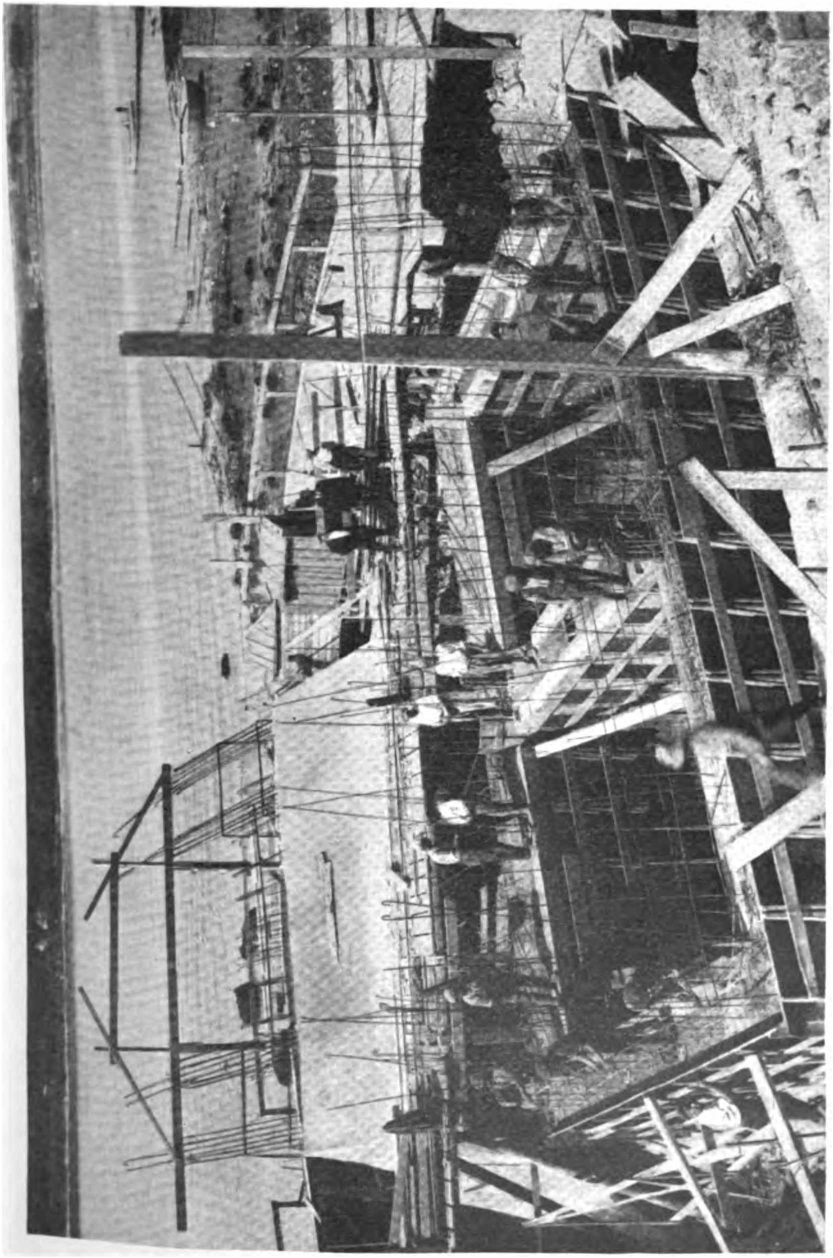


Fig. 15.—Southern Abutment and Springing.

which at the appointed time were tapped and the caisson let down on to trolleys and rails, thence launched on a favourable tide, and towed across the stream to the position of the north pier. *Fig.* 20 shows this huge pre-cast structure being manœuvred into its first location. The timber boxes projecting along the longer sides are to provide added buoyancy when floating out.

The design of the caisson is shown in the sketch in *Fig.* 18. The lower portion will eventually form a permanent part of the job, namely, the south pier; the top cylindrical work, however, above *PP*, is for executive purposes only, and will be knocked away when its function is fulfilled. It will be seen that the working chamber is about 6 ft. 6 in. deep by about 59 ft. long and 52 ft. wide. Above this are sixteen airtight compartments for filling or voiding of ballast as required. This brings us up to the level (*PP*) of the permanent work, above which are three cylinders of concrete about 2 in. thick supporting the top working deck (*TT*) and housing the access shafts and air locks admitting to the working chamber. There are two shafts for material and one for personnel. The temporary timber upper deck (*TT*) carries Ingersoll Rand compressors in duplicate for supplying air below, a small timber gantry for handling material, and all such essential equipment. The whole of this shell is executed in aluminous cement concrete in the following approximate proportions: stone, 1·75 parts; stone dust and sand, 1·26; to 1 part aluminous cement.

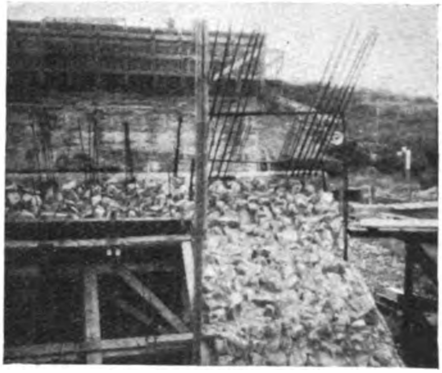


Fig. 16.—Springing from Riverside: showing Cyclopean Concrete.

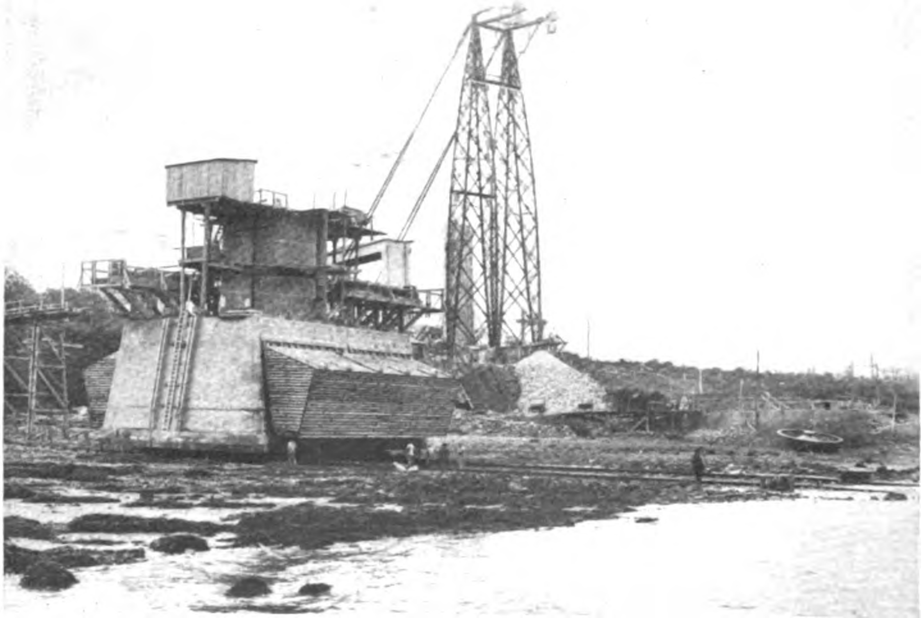
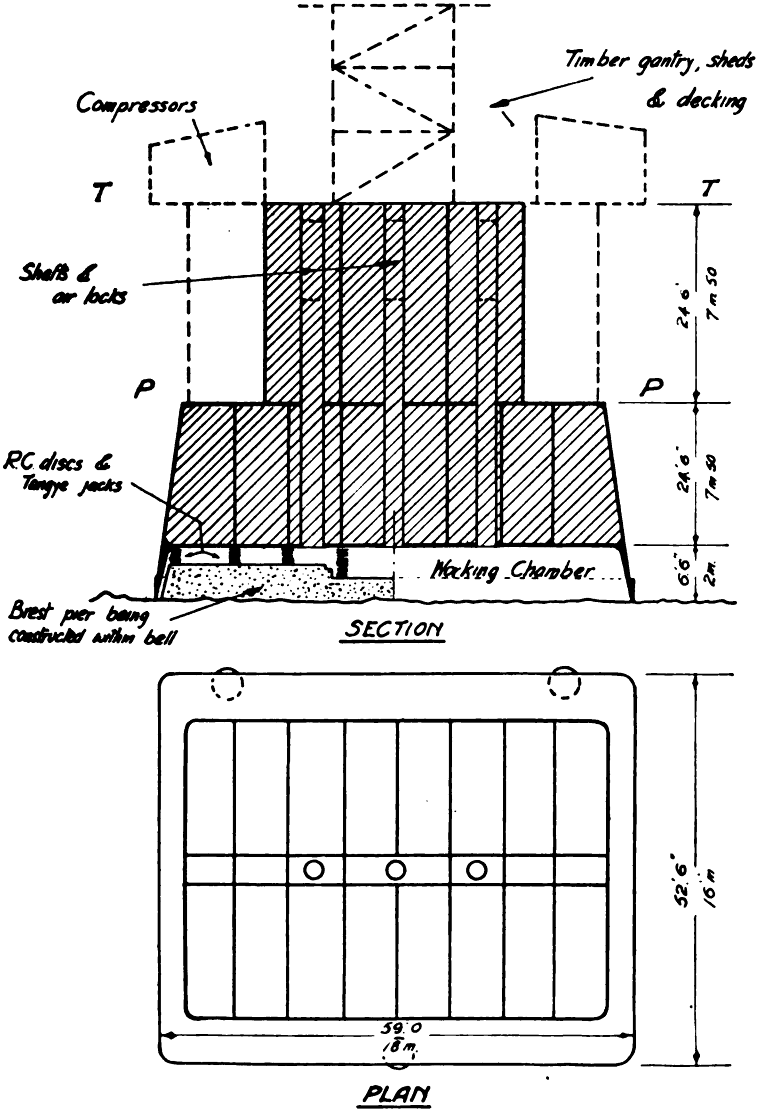


Fig. 17.—View of Caisson before Launching.



CAISSON Fig. 18

The north pier was selected for the earlier construction on account of its lesser depth, due to a submerged hillock on the river bed. By means of the anchors previously described the caisson or bell was held in position while water was admitted and thus gradually sunk into position on three prepared seatings. When sufficiently ballasted to render it stable and firm against all tidal conditions, compressed air was pumped into, thereby replacing the water in, the working chamber, which was thus rendered available for workmen. The bottom of the river was first prepared and the actual construction of the north pier begun. The subaqueous operations are continuous; when the writer visited the job, twenty men were at work and there were three shifts of 8 hours per day. The pressure of compressed air has to be varied naturally with the rise and fall of tide. The compressors on deck are kept active and the excess of air escapes beneath the river and rises in bubbles around the bell.

It must be appreciated that in this position the caisson is being employed simply as a diving bell, the immediate object in view being the construction of the north pier within the working space. This is accomplished by filling the cham-

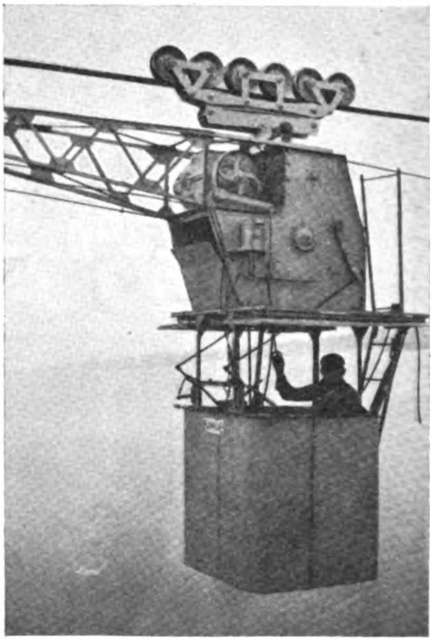


Fig. 19.—Cableway Trolley and Operator's Box.

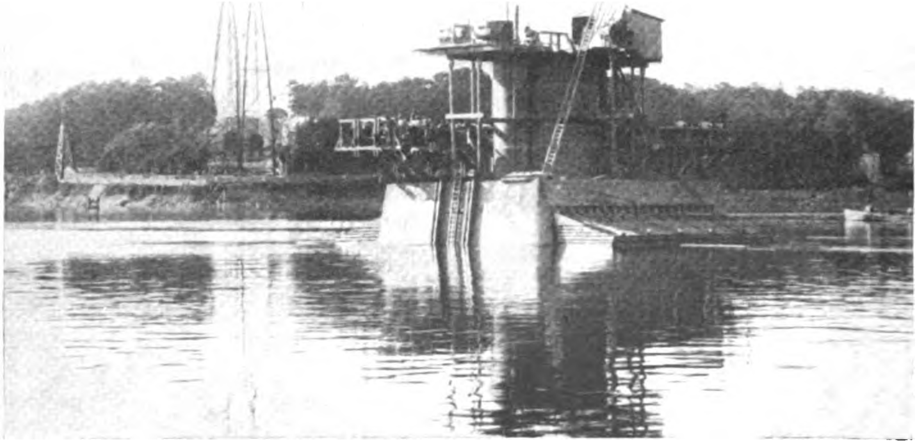


Fig. 20.—Caisson being Floated into Position.

ber as high as possible with concrete in stages and divisions, allowing it to harden; then raising the whole caisson by the aid of Tangye hydraulic jacks; filling up the height gained by inserting pre-cast concrete discs or packing pieces; and the process continued successively. The method is illustrated diagrammatically in *Fig.* 18.

In this manner this pier can be brought up solid until its upper surface is high enough for intertidal work. After being brought to this height the caisson will be unballasted, refloated, and towed into the position of the southern pier, where it will be grounded in its final position in deeper water than the first pier. Here the permanent portion will be filled up solid with concrete, the superstructure, air locks, shafts, etc., cut away, and the whole shaped up to take the springings of the ribs.

When it is realised that the position is such that an ugly sea and gale will follow a calm within a few hours and without warning, it will be conceded that the contractors and designer have grappled with the problems of this difficult and unprecedented undertaking with an ingenuity and audacity that evoke our sincere admiration.

The Concrete Year Book, 1927.

THE 1927 Edition of the "Concrete Year Book," edited by Oscar Faber, O.B.E., D.Sc., M.Inst.C.E., and H. L. Childe (Editor of Concrete Publications Limited), is now ready. This year the volume is still further enlarged to 440 pages. It is now in its fourth year, and is a standard work of reference in the concrete world.

The Handbook Section contains authoritative chapters on practically every aspect of concrete and reinforced concrete design and construction, embracing the latest practice at home and abroad. No attempt is made at giving individual opinions, but to present in concise and convenient form specifications or methods which are either standard practice or recommendations formulated after thorough investigation by competent bodies. Tables for reinforced concrete design, a great deal of memoranda of everyday use, a complete bibliography of books on concrete and allied subjects, etc., are included. The whole of this section, of over a hundred pages, has been thoroughly revised and brought up to date.

The Directory Section is the only complete directory of the concrete industry published in this country, classified under different headings for ease of reference, and the enlargement of this section is largely responsible for the increased size of the volume. It includes all new entries and changes of addresses received up to the middle of December last, and further sections have been included for ease of reference. A new feature this year is a classification of the "Machinery and Plant" and "Concrete Products" Sections, under which all kinds of machinery and pre-cast concrete are listed together with manufacturers' names under separate headings. A complete list of trade names and brands in use in the industry is a valuable feature.

The Catalogue Section contains full particulars of the businesses or products of a large number of firms connected with or catering for the concrete industry, and is invaluable to anyone seeking a firm of contractors to carry out special kinds of work, or a machine or product for a special purpose. This section is also considerably increased in size.

The volume may be obtained (price 2*s.* 6*d.* net; by post 3*s.*) from Concrete Publications Limited, 20 Dartmouth Street, Westminster, S.W.1.

Concrete at Bevans Cement Works.

THE new Bevans Works at Northfleet of the Associated Portland Cement Manufacturers, Ltd., is now rapidly nearing completion. Ultimately the output will be 10,000 tons a week, so that it can claim to be the largest cement works in Europe. This large output will be obtained with four rotary kilns 250 ft. in length and seven tubular grinding mills. The simplicity of this plant is in marked contrast with the process used at the beginning of the present century, when the same output would have required no less than 400 kilns of the capacity then in use.

Naturally the buildings, silos, wash-mills, and other structures are practically all constructed of reinforced concrete, and in addition there have been many minor applications of reinforced concrete, such as elevator towers, hot-air flues, etc., described in the following notes. In conjunction with the works a reinforced concrete jetty of unique design has been built to allow large vessels to come alongside; we shall describe this jetty in a future number.

At the start of the construction very great difficulty was experienced in obtaining a sufficient supply of skilled labour, and every endeavour was made to economise in this respect. For this reason principally "Metaform" steel shuttering was introduced and used wherever possible. In fact, it may be said that timber shuttering was only used for difficult corners and special designs of which there was not enough to warrant the expense of special steel forms. Wherever there was a straight piece of work these forms were used and gave very satisfactory results both from a cost and speed point of view.

"Ferrocrete" rapid-hardening Portland cement was used almost exclusively for all the reinforced concrete, and although a large proportion of the work was done in extremely cold weather it was nearly always possible to get a lift on wall work every day. When this was not achieved

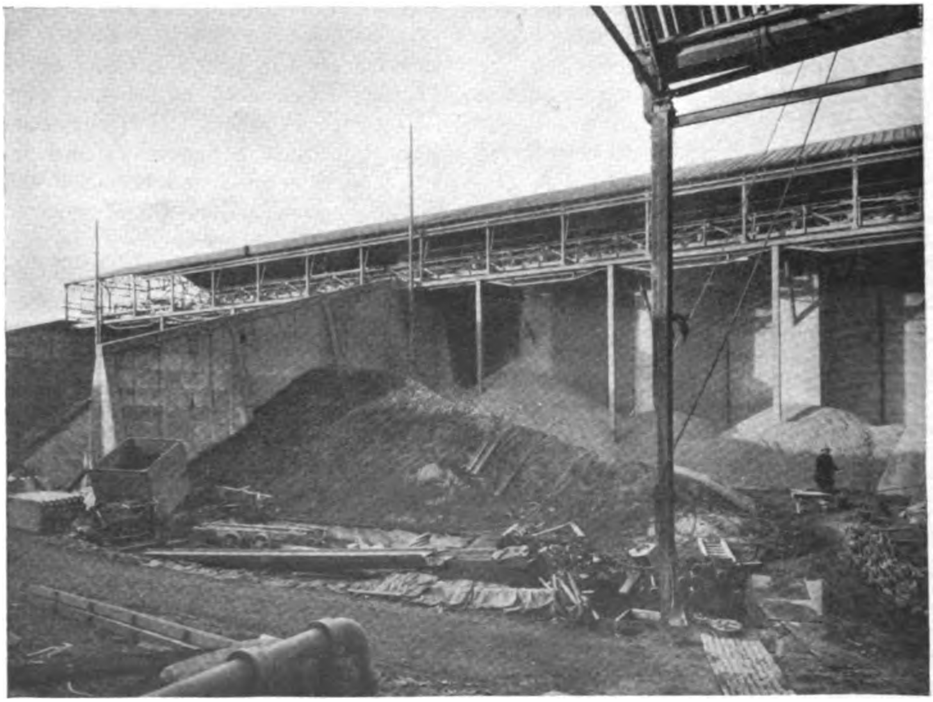


Fig. 1.—Clinker Hoppers.

the delay was not due to the concrete being too green, but to some other cause, such as the volume of shuttering being too large to handle in the time, or the volume of concrete being too great.

An incident of considerable interest occurred during the construction of the clinker hopper. One of the floor slabs, which was about 2 ft. thick, was poured just before a spell of frost lasting about ten days. During the whole of this period, although the ground was frozen hard all around, there were no signs of freezing on the slab, on which stood shallow pools of water. It is evident that " Ferrocrete " in setting develops quite an appreciable quantity of heat which at least very considerably reduces the risk of freezing.

Washed sand and ballast was used exclusively and this was supplied by the Stone Court Chalk, Land & Pier Co., Ltd. Practically throughout the work a standard mix of 4 cu. ft. of ¾-in. ballast, 2 cu. ft. of ¼-in. sand and 1 cwt. of cement was used, and 6-in. test cubes were taken nearly every day on various portions of the plant. These cubes were filled by the ordinary workmen from a batch actually being poured on the job, and no special tamping or precautions were permitted. The average crushing strength of the concrete at seven days was about 4,000 lbs. per sq. in., and at 28 days 5,000 lbs.

Clinker Store.

One of the largest, and possibly the most interesting, structure is the clinker store, which is shown in *Figs.* 1 to 4. This is 173 ft. by 81 ft., and 47 ft. deep at its deepest point. It is capable of storing 15,000 tons of clinker.

About three-quarters of the total load is carried on the solid chalk or on old brick walls 3 ft. thick which used to support drying floors. The spaces between these walls have, however, now been filled, and the floor of the hopper at this point is carried on the old walls ; the slab for this has been made sufficiently strong to span from wall to wall, as it was not considered that the new filling could satisfactorily be made to carry any load. This slab in some cases reaches a thickness of 18 in., and is reinforced with about 0·75 per cent. of steel in 1-in. diameter bars.

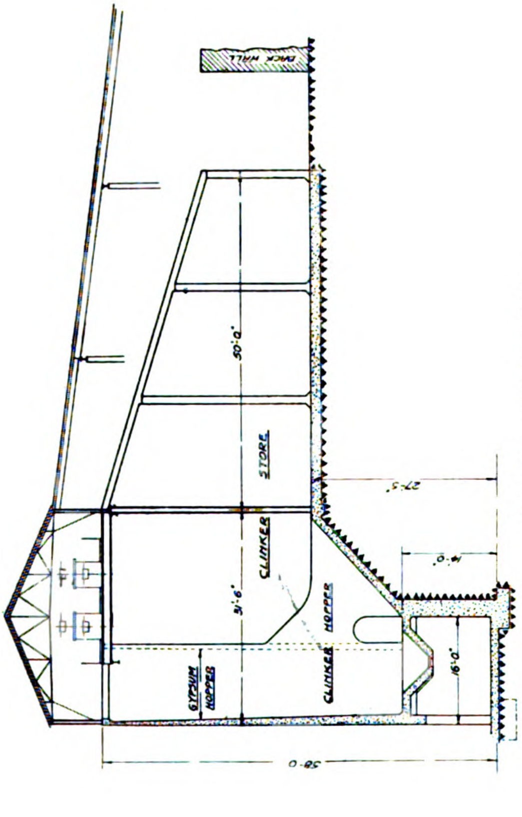
As will be seen from the drawings, the front portion of the hopper for a width of 10 ft., and the entire length, is carried on a series of concrete columns. The floor of the hopper is of heavy beam and slab construction, of rather a complicated nature owing to the necessity for providing fourteen hopper-shaped outlets in the length. As the load per square foot here is about 5,000 lbs., it will be understood that some of the beam work is very heavy. Most of the reinforcing bars are about 1⅛ in. diameter, and the slab is 14 in. thick in most parts. Some of the beams have as much as 18 square inches of steel.

A peculiarity of the design of this hopper is that, if the hopper is filled up till the heap of clinker dies out at the toe of the slab, the front wall for about three-quarters of its height has no opposing wall to give a reaction, and the tie (see *Fig.* 2) which keeps the wall up has an anchorage in the horizontal slab only. At first sight this may appear a rather hazardous and uncertain arrangement, but further consideration makes it evident that as the clinker in the hopper is at rest or in equilibrium all the pressure on the front wall above slab level must be balanced by the friction of the clinker on the slab. The ties are, therefore, made to die out gradually in the slab.

When the hopper is filled still farther, so as to reach the top of the existing back wall (see *Fig.* 2), the case is somewhat altered. Considering a vertical section immediately outside the slab, it is evident that there is a horizontal thrust on the hopper clinker with no visible tension member. The whole hopper, together with its load, must therefore be receiving this thrust, and as there is no other balancing force it is evident that the thrust must be countered by the friction of the underside of the slab on the supporting chalk, old walls, etc. Calculations carried out on this assumption reveal that the structure is quite safe.

Another feature in the design of this hopper is the anchorage for the end walls. Owing to the requirements of the surrounding plant it was not possible to have large buttress walls, and in effect these walls have been treated as vertical beams tied together at the top and the bottom —at the top through the steelwork carrying the conveyors, and at the bottom through the bottom slab.

The top anchorage is further held, at



SECTION ON A-B OF PLAN

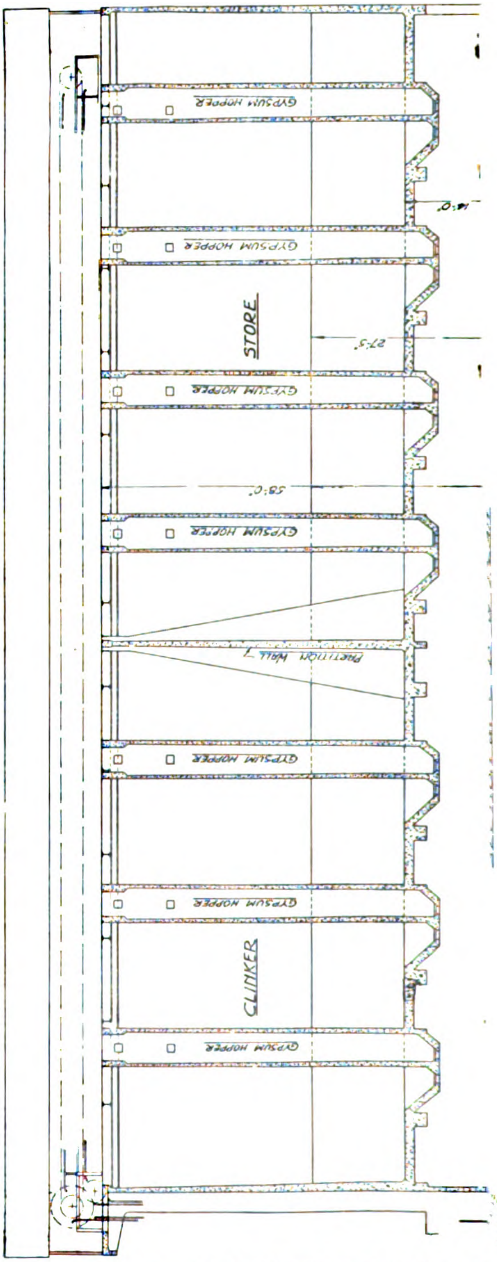
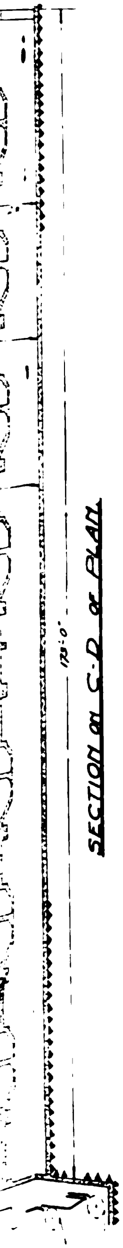
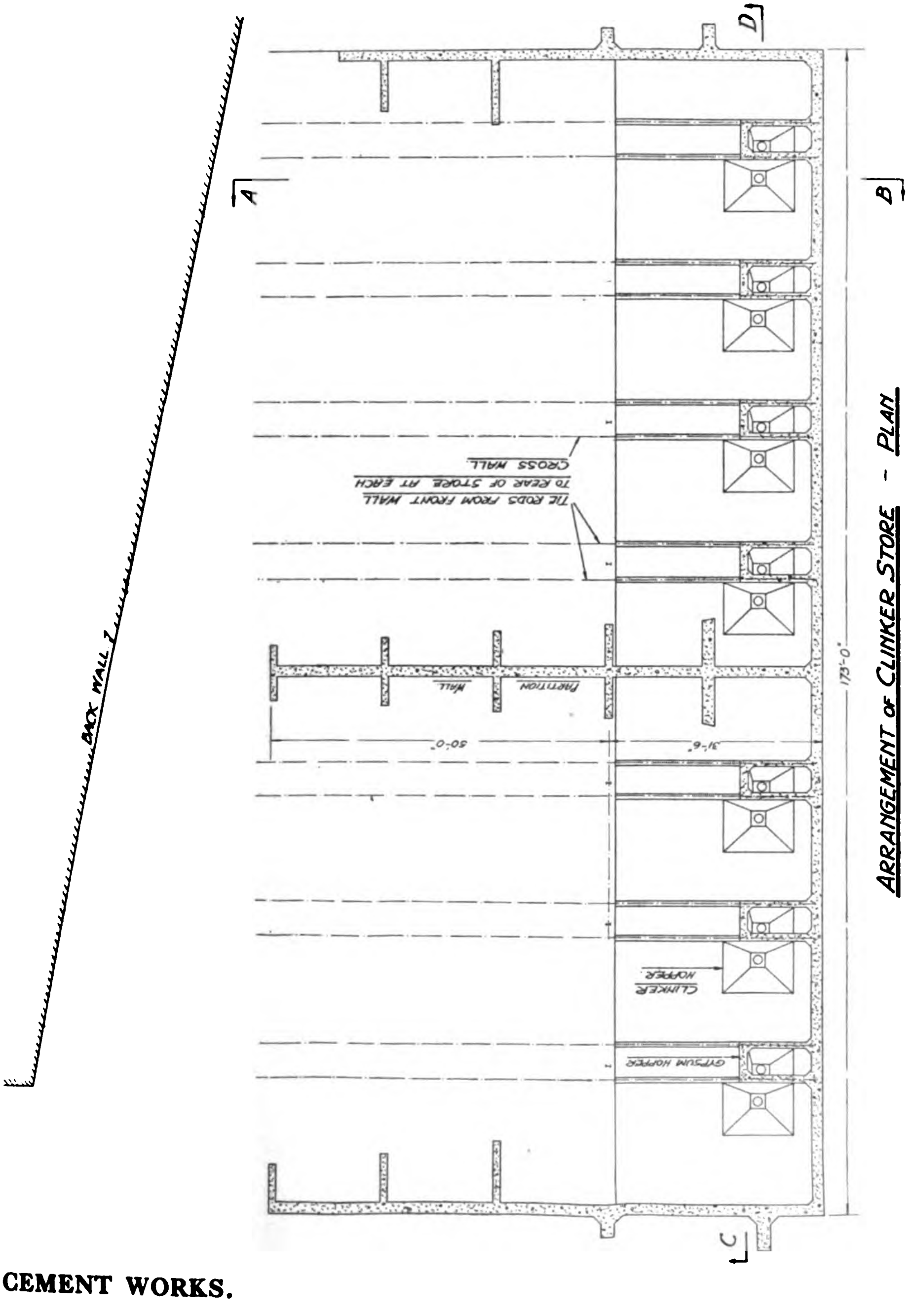


Fig. 2.—CLINKER STORE AT



SECTION ON C-D OF PLAN



ARRANGEMENT OF CLINKER STORE - PLAN

RE AT BEVANS CEMENT WORKS.

about its centre point, by being fixed to the heavily buttressed partition wall which forms a partition near the centre of the hopper.

The consulting engineer for the hopper was Dr. Oscar Faber, O.B.E., D.Sc., M.Inst.C.E., and the construction was carried out by Mr. J. B. Lingham, of Northfleet, under the supervision of the Company's own Engineer.

Cement Silos.

Most of the cement made at these works is stored in circular reinforced concrete silos, each capable of holding 2,000 tons of cement. There are at present eight of these silos, in two rows of four as shown in *Figs.* 5 to 8. It is, however, probable that this number will be considerably augmented in the near future.

Each silo is 32 ft. diameter and 84 ft. high from ground level. Considerable space at the bottom is, however, taken up with the tunnel and cement extracting mechanism. Four of the silos are plain circular tanks above tunnel level, and the design of these is therefore comparatively

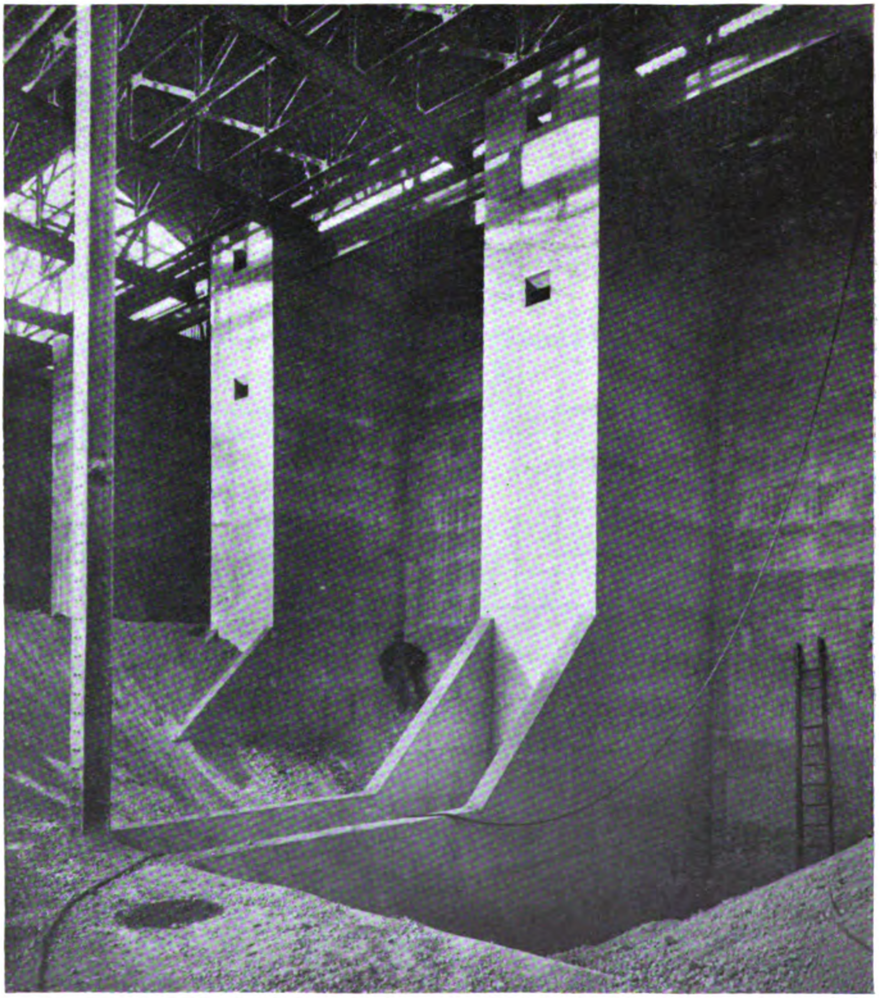


Fig. 3.—Clinker Hopper.

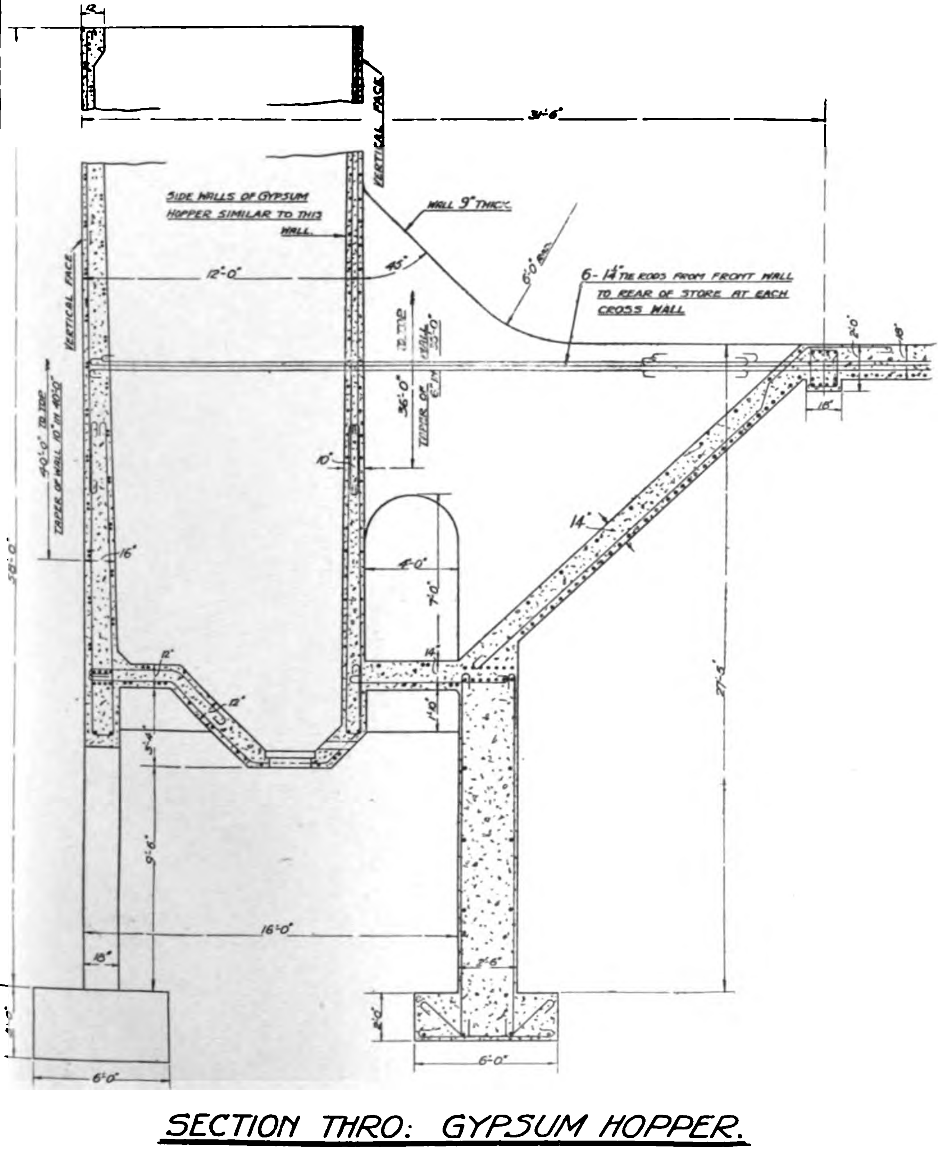

12
VERTICAL FACE
31'-6"
SIDE WALLS OF GYPSUM HOPPER SIMILAR TO THIS WALL.
WALL 9" THICK
6'-0" RAD.
12'-0"
45°
VERTICAL FACE
6-1¼" TIE RODS FROM FRONT WALL TO REAR OF STORE AT EACH CROSS WALL
2'-0"
18"
18"
12" TOP
36'-0"
TAPER OF WALL 6" IN 33'-0"
40'-0" TO TOP
TAPER OF WALL 10" IN 40'0"
10"
58'-0"
16"
4'-0"
7'-0"
14"
14"
12"
12"
1'10"
3'-4"
27'-5"
9'-6"
16'-0"
18"
2'-6"
3'-0"
2'-0"
6'-0"
6'-0"
SECTION THRO: GYPSUM HOPPER.

Fig. 4.—Clinker Hopper.

simple. The remaining silos, however, are each subdivided into bins with a well and staircase up the centre. This is done in order to comply with customers' requirements when cement to a special specification is required, and holes are arranged at each landing of the staircase so that samples for testing purposes may be drawn from any bin and at any depth.

The addition of these partition walls considerably complicates the design, as not only must the partition wall be capable of standing up when adjacent bins are empty, but the outside wall must also be strong enough under these conditions. If all the bins are full the outside wall is obviously in pure tension, but if this tension is removed through some of the bins being empty, part of the load must be carried by the wall as a curved beam.

In the present case this has resulted in the thickness being increased on an average by ½ in. The area of the steel is, however, on the average, lower, as the

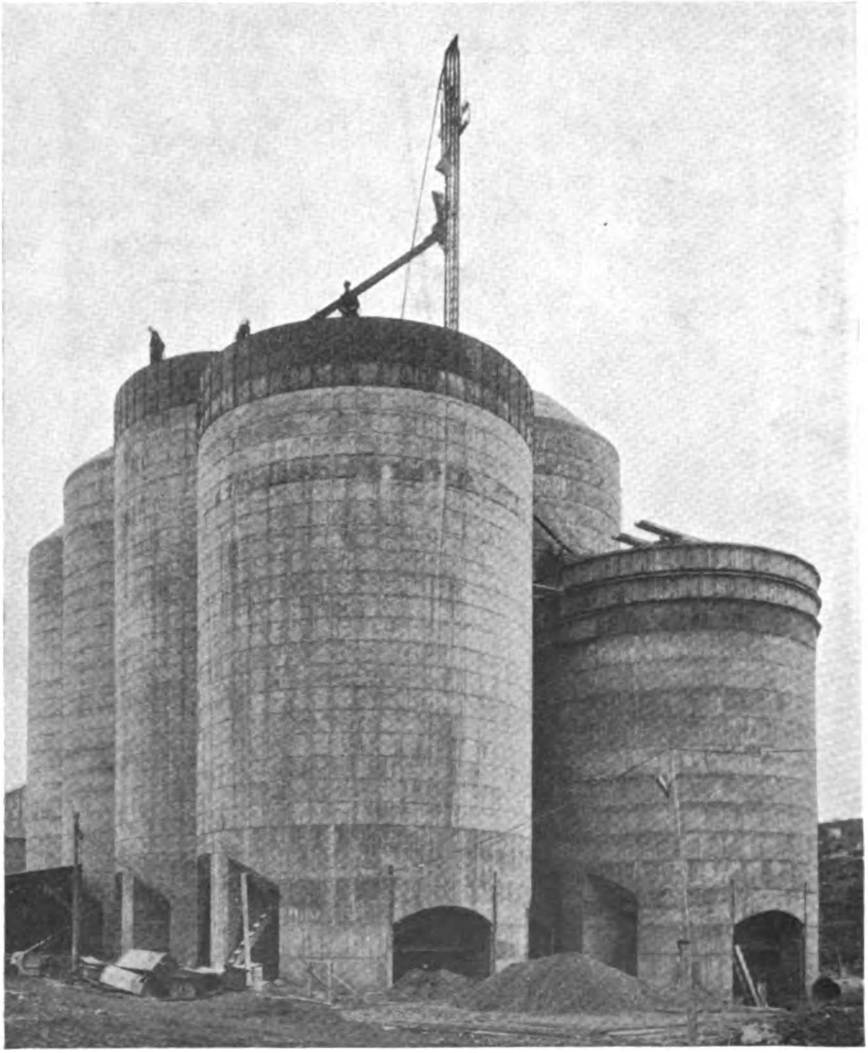
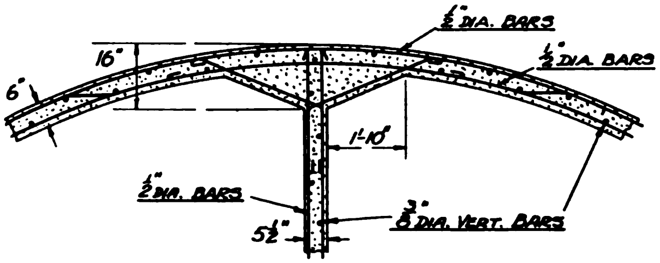
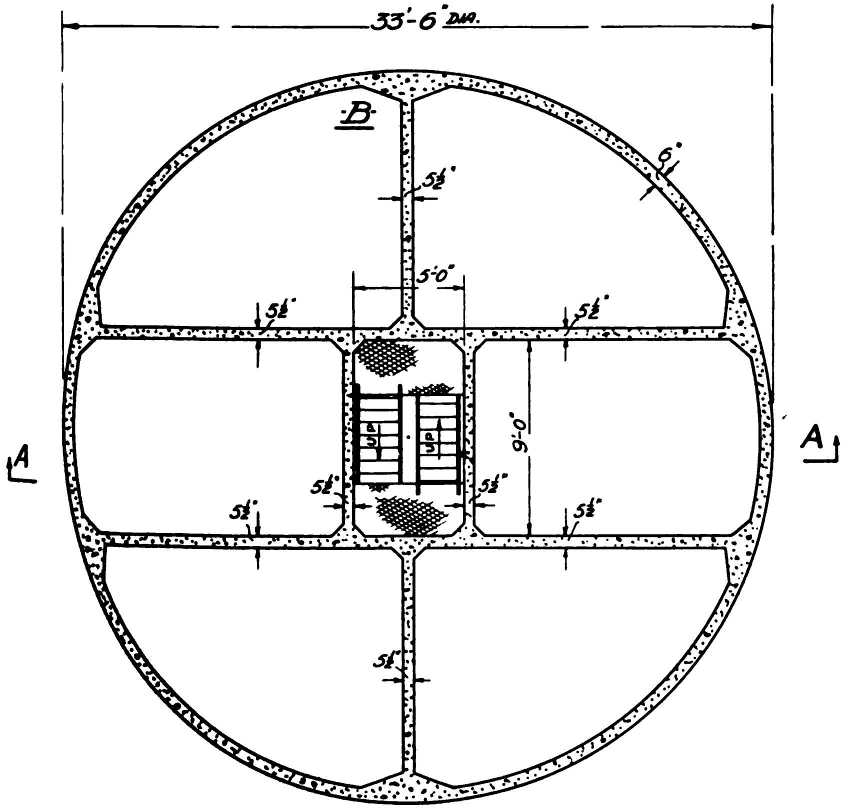


Fig. 5.—Cement Silos.

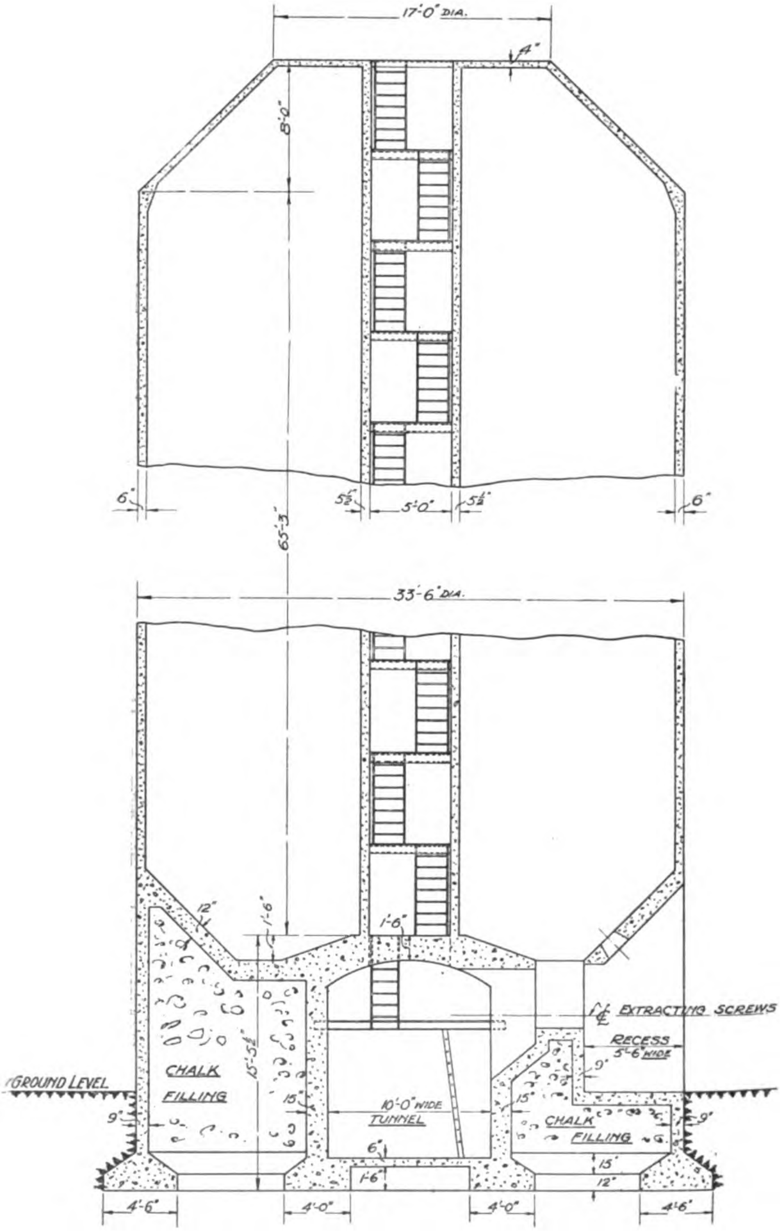


DETAIL AT -B-



SECTIONAL PLAN

Fig. 6.—Cement Silos.



SECTION ON A.A.

Fig. 7.—Cement Silos.

reduction in horizontal pressure in the small bins more than compensates for the extra steel required to take up the bending stresses.

The horizontal pressures were calculated by Janssen's formulæ, and these vary from 850 lbs. per sq. ft. at the bottom of the plain circular bins to 340 lbs. in the case of the partition bins.

At the bottom of the plain silos is a tunnel with a roof of 11 ft. 3 in. span, on which the pressure per sq. ft. is 3,500 lbs. The foundations are on solid chalk and a pressure of 5 tons per sq. ft. has been allowed here.

These silos were built to designs prepared by Messrs. Edmond Coignet, Ltd.

Coal Mill.

The coal mill is built entirely of reinforced concrete, and measures 65 ft. by 41 ft. by 32 ft. to the eaves.

The construction consists essentially of 18 in. by 18-in. piers reduced to 18 in. by 12 in. at the top and spaced at about 12 ft. 6 in. centres. The space between the piers is filled in with reinforced concrete walls 6 in. thick. The columns, or piers, are each reinforced with four ⅞-in. diameter rods with ¼-in. diameter lacing, and the walls have ½-in. vertical rods spaced about 4 ft. centres with ⅜-in. horizontal rods at a pitch of 12 in.

Raw Coal Hopper.

The coal mill contains a small reinforced concrete coal hopper used for the supply of coal to the grinding mills. Its capacity is about 60 tons. *Fig.* 9 shows the general outline. The hopper is 58 ft. long by 9 ft. wide, outside dimensions, and is provided with six outlets, one to each grinding mill. There is also a partition in the centre, so that one-half can be cleaned out, or a block cleared, while the other half remains at work. Two parallel rows of 12-in. square reinforced concrete columns support the hopper at about 12 ft. above floor level. It may be noted that these columns have no bracing; lateral stiffening is, however, provided by the top deck which runs from end to end of the building.

The reinforcement throughout is round steel bars varying from ⅞ in. diameter in the column and main beams to ⅜ in. diameter in the slabs. In order to avoid complicated and expensive shuttering the floor of the hopper was made flat in longitudinal section, and the corners were filled in with dry filling and faced with concrete.

Powdered-Coal Hoppers.

Adjacent to, and forming one side of, the coal mill is the powdered-coal store shown in *Fig.* 10. This hopper is 64 ft. by 20 ft. by 39 ft. high to the top deck, which carries the feeding conveyors. The net capacity of the hopper is about 400 tons of powdered coal, and, as in the case of the dry coal hopper, a partition wall

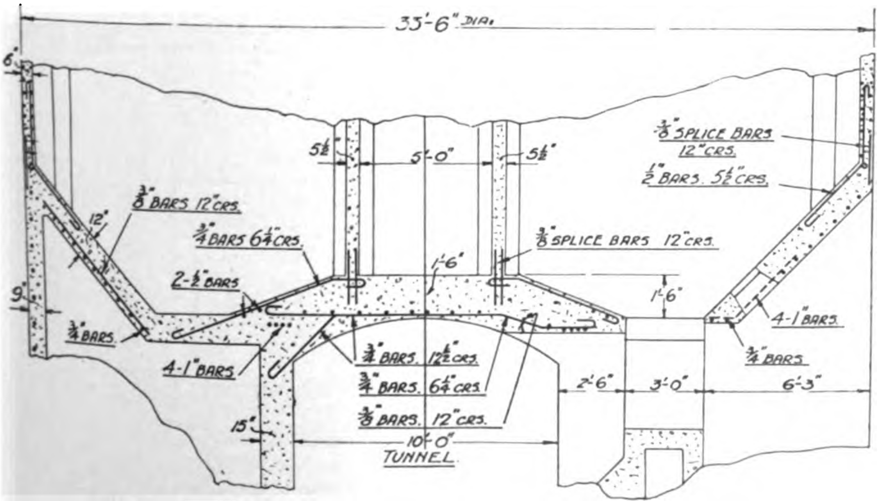


Fig. 8.—Cement Silos: Detail over Tunnel. (*See Fig.* 7.)

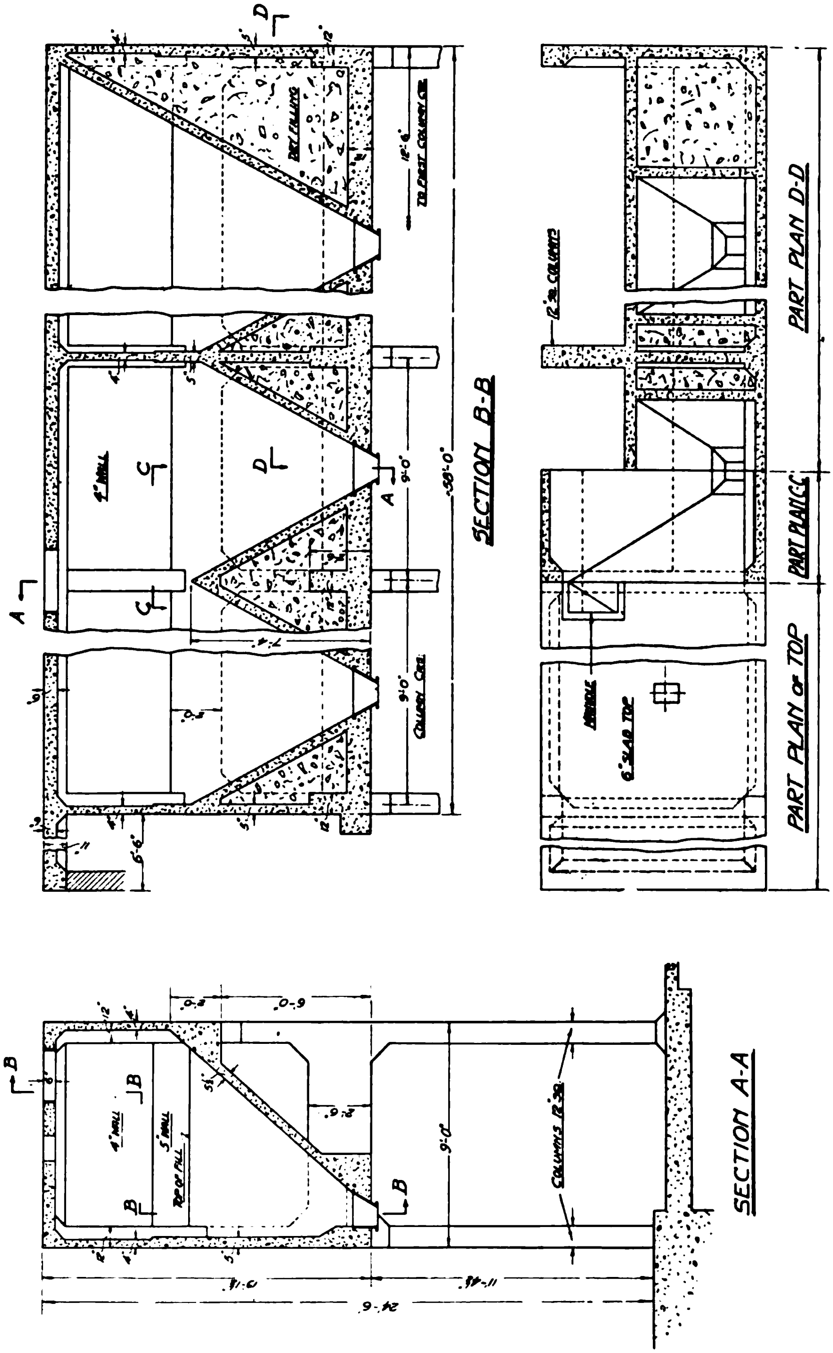


Fig. 9.—Raw Coal Hopper.

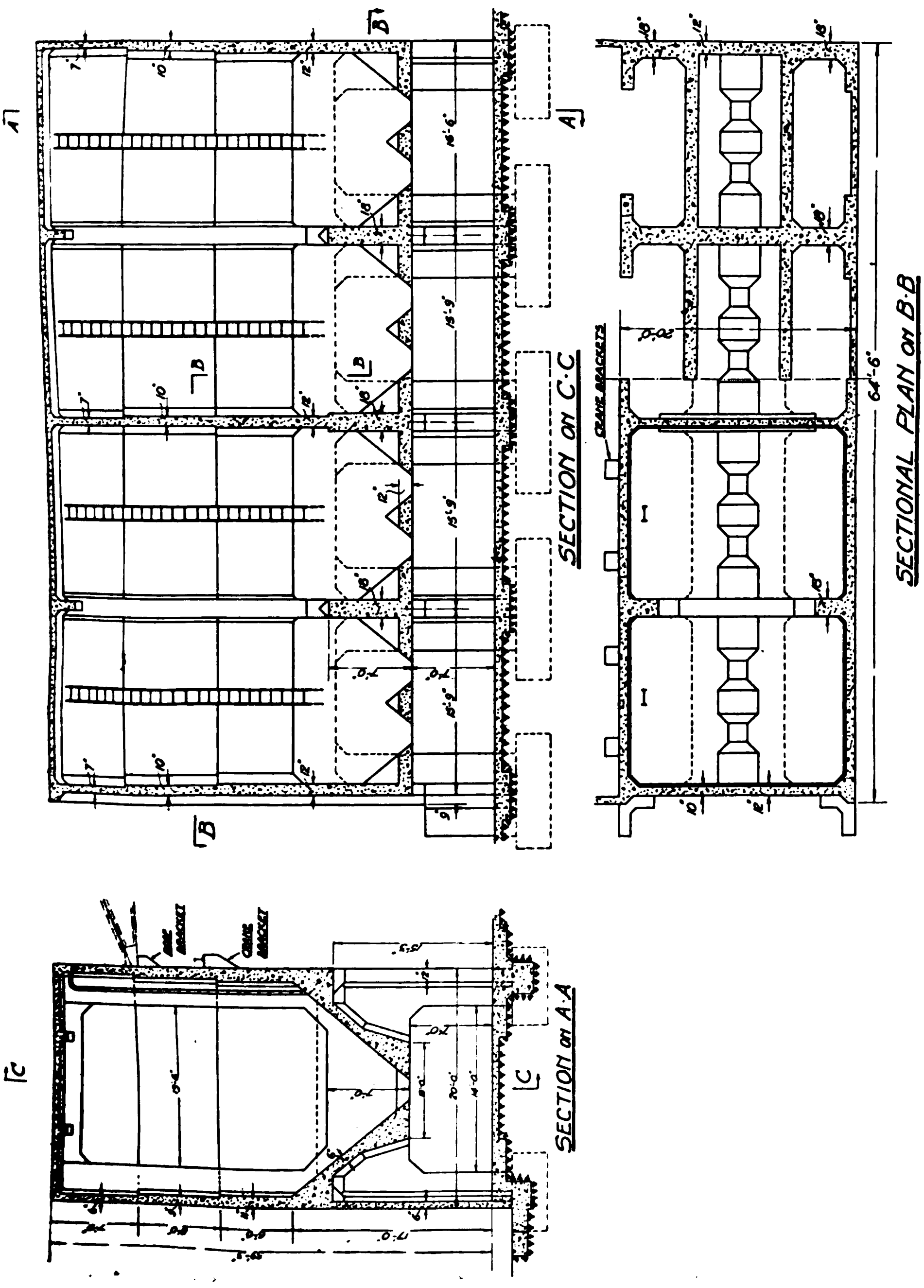


Fig. 10.—Powdered Coal Hopper.

is provided so that half may be emptied if required without interrupting the working of the other half.

As the ground was rather uncertain here, it was not considered advisable to impose a load exceeding 1 ton per square foot, and the supporting columns, which are tee-shape, are therefore carried on two parallel beam-and-slab foundations. This gives an area of 1,400 sq. ft. and a foundation load of rather less than the above figure.

The hopper is peg-top shape in cross section, but flat bottomed in longitudinal section in order to avoid expensive shuttering, the corners being dry filled and covered with concrete.

The main load is transferred to the columns by a series of cross beams 7 ft. deep, which in turn carry the inclined slab and beam construction forming the bottom.

The vertical walls of the hopper, which vary from 6 in. to 12 in. thick, are divided into panels of 16 ft. centres (the same spacing as the columns) by internal vertical beams tied together top and bottom, and the wall is treated as a slab carried by these beams.

The top of the hopper is completely enclosed by a beam and slab construction. The reinforcement consists entirely of round rods varying from 1⅛ in. diameter in the main beams to ½ in. and ⅜ in. in the slabs.

Slurry Mixers.

These are shown in *Fig.* 11. They are plain circular tanks made of reinforced concrete, with nothing remarkable in the design except the size. They are 66 ft. diameter and hold about 1,500 tons of slurry. The circular form was obtained by the use of straight "Metaforms."

Elevator Casings.

An interesting feature of the coal and cement-handling plant is that the elevator casings (*Fig.* 12) are of reinforced concrete. This is a particularly useful arrangement for coal handling, as it is found that steel casings only last two or three years under the combined corrosive action of moisture and sulphur in the coal.

These casings are in some cases 60 ft. high, and are made of 2½-in. thick concrete, reinforced with expanded metal with one ⅞-in. diameter rod in each

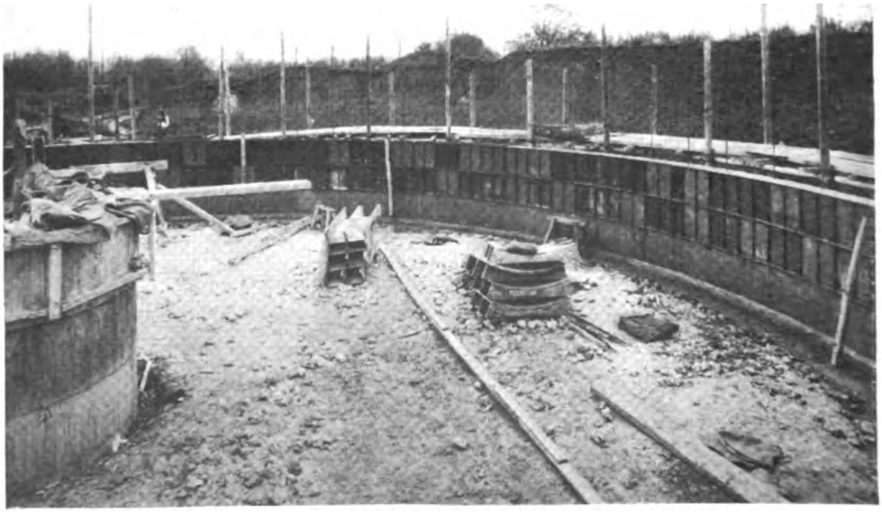


Fig. 11.—Slurry Mixers.

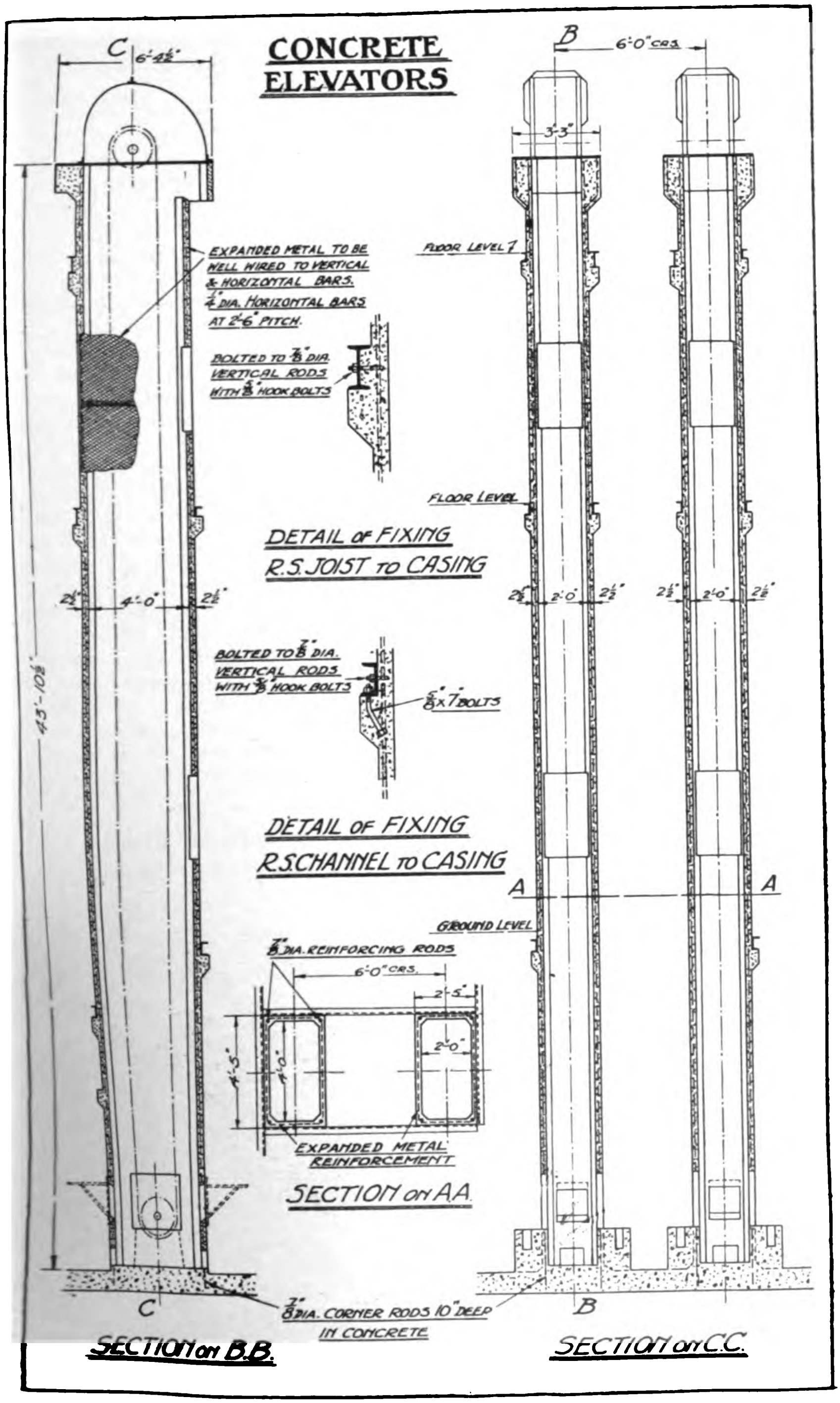

CONCRETE ELEVATORS
C
6'-4½"
43'-10½"
EXPANDED METAL TO BE WELL WIRED TO VERTICAL & HORIZONTAL BARS.
¼" DIA. HORIZONTAL BARS AT 2'-6" PITCH.
BOLTED TO ⅞" DIA. VERTICAL RODS WITH ⅝" HOOK BOLTS
FLOOR LEVEL
FLOOR LEVEL
DETAIL OF FIXING R.S. JOIST TO CASING
2½"
4'-0"
2½"
BOLTED TO ⅞" DIA. VERTICAL RODS WITH ⅝" HOOK BOLTS
⅝" x 7" BOLTS
DETAIL OF FIXING R.S. CHANNEL TO CASING
⅞" DIA. REINFORCING RODS
6'-0" CRS.
2'-5"
4'-5"
4'-0"
2'-0"
EXPANDED METAL REINFORCEMENT
SECTION ON AA
⅞" DIA. CORNER RODS 10" DEEP IN CONCRETE
B
6'-0" CRS.
3'-3"
2½"
2'-0"
2½"
2½"
2'-0"
2½"
A
A
GROUND LEVEL
C
B
SECTION ON B.B.
SECTION ON C.C.

Fig. 12.—Concrete Elevator Casings.

corner. Cast-iron door frames are built in at suitable points to give access to the gear, and at the top of the casing the walls are thickened up to receive a base plate carrying the top gear.

A further point of interest is that the walls of these elevators, 2½ in. thick only, were built with "Metaforms" and were found to be absolutely plumb for the whole height of 60 ft. when tested.

Footbridge.

Passing through the works is a right-of-way, a considerable portion of which is at a high level and which in the old plant was on solid ground. Under the reconstruction scheme it was found necessary slightly to divert this path, and also, for convenience in getting about the works, to cut away the supporting ground down to the general factory level. This left the path in the air, and also on a curve, for a distance of about 190 ft.

Various schemes were suggested to carry this path, but finally it was decided to build the substantial reinforced concrete bridge shown in *Figs.* 13 and 16. This bridge consists of six spans of 32 ft., each rising from a height of 10 ft. at the lower end to 20 ft. at the higher end above normal ground level. The width of the path is 8 ft. The spans are carried on 15-in. square columns in pairs, joined and braced together at the top by a deep beam so as to form a trestle. The design was further complicated by the fact that a 9-in. gas main had to be carried, and this is passed through a hole in each of the beams.

The bridge spans each consist of a pair of tee-beams with the upper flange forming the deck of the bridge. The beams are 2 ft. 6 in. deep, and the deck slab 6 in. thick.

As it was desirable to prevent loitering on the bridge as much as possible, the sides are entirely enclosed to a height of 6 ft. by a concrete slab-and-post construction. The method of doing this was rather novel, and is worth describing in some detail. It will be noted from the drawing that the posts are about 8 ft. apart, and the moulds for these and also for the top rail were made in halves longitudinally. In putting these halves together, a sheet of "Trussit" about 1½ in. larger all round than the panel was clamped between them and the concrete for the posts and rails poured. At the same time the concrete rail at deck level was poured so as to enclose the lower edge of the sheet. After the posts had hardened the shuttering was removed and the mesh reinforcement plastered both sides.

The reinforcement throughout consists of round steel bars varying from 1⅛ in. diameter to ⅜-in. diameter in the slab.

Hot-Air Flues.

In various other plants of the Company

In the Quarry.

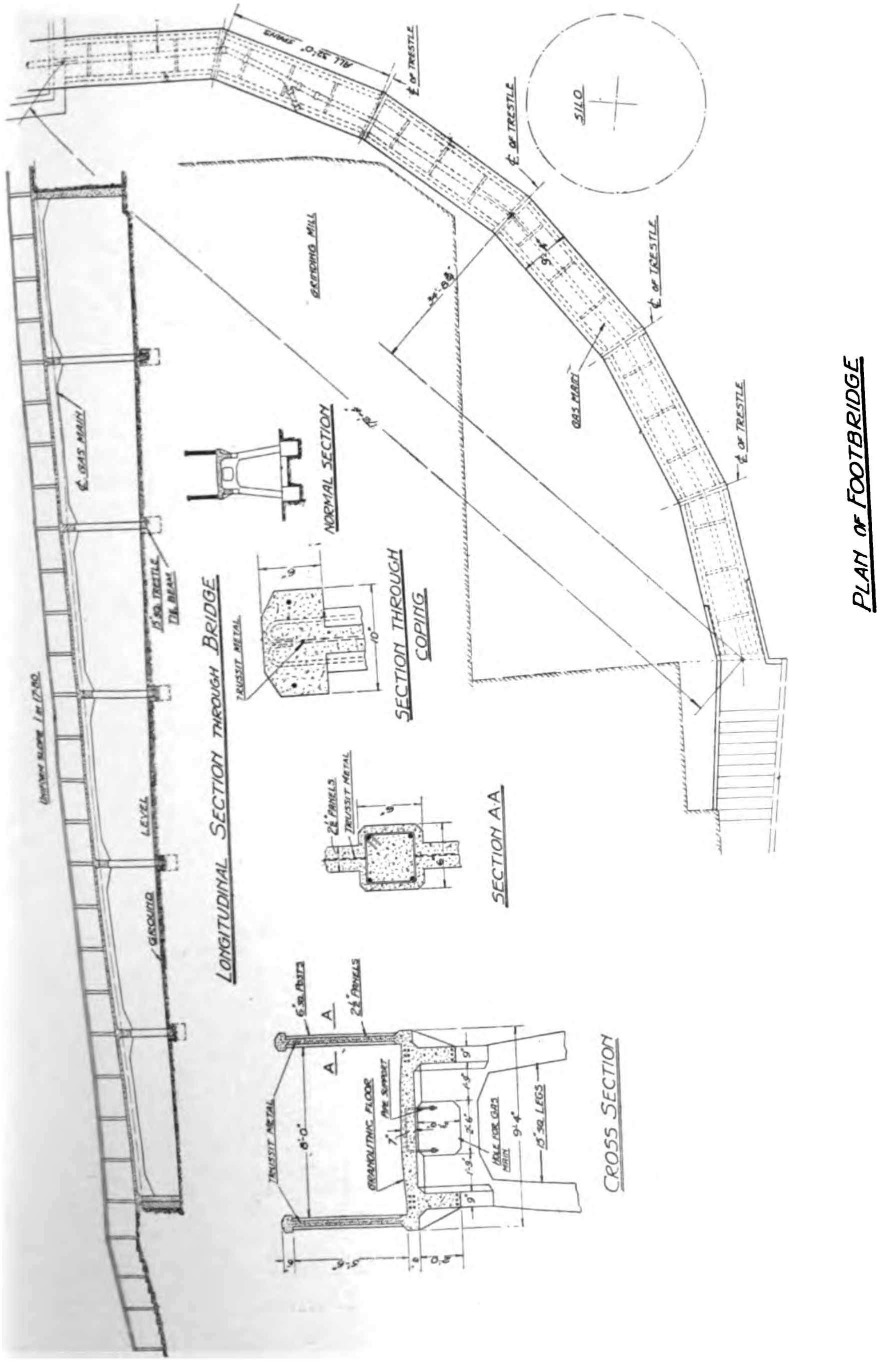
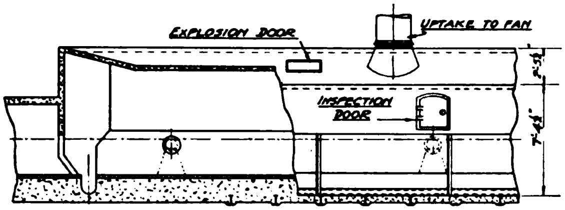
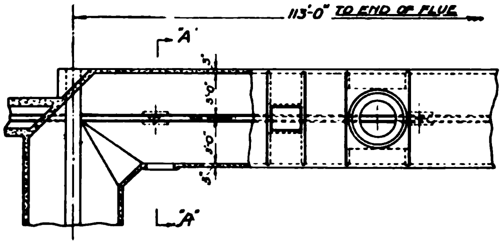


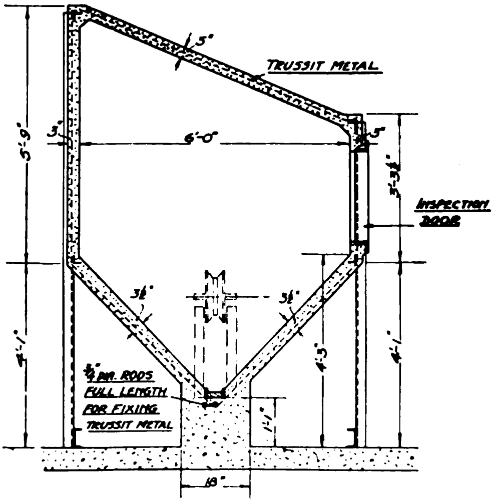
Fig. 13.—Footbridge.



ELEVATION

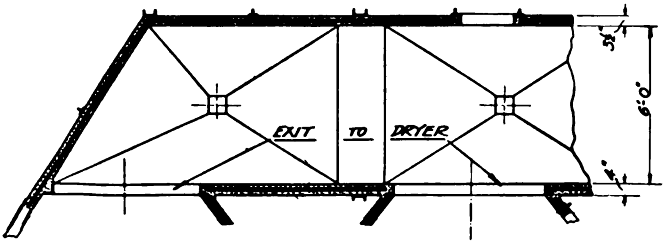


PLAN

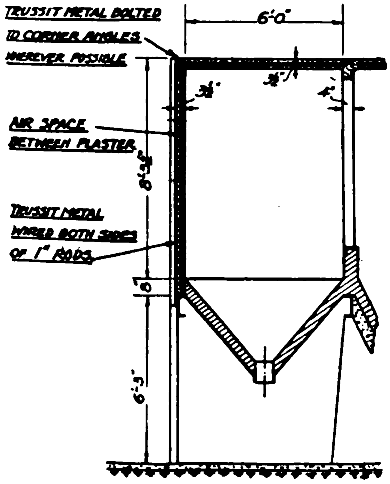


ENLARGED SECTION ON "A A"

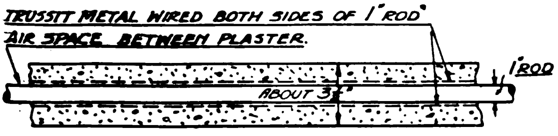
Fig. 14.—Hot Air Flues in Concrete.



SECTIONAL PLAN


TRUSSIT METAL BOLTED TO CORNER ANGLES WHEREVER POSSIBLE
6'0"
3½"
3½"
4"
AIR SPACE BETWEEN PLASTER
8'5½"
TRUSSIT METAL WIRED BOTH SIDES OF 1" RODS
10"
6'5"

CROSS SECTION


TRUSSIT METAL WIRED BOTH SIDES OF 1" ROD
AIR SPACE BETWEEN PLASTER.
1" ROD
ABOUT 3½"

SECTION THRO: PLASTER SIDES AND ROOF.

Fig. 15.—Hot Air Flues in Concrete.

the brick-built hot-air flues to and from the coal dryer have given considerable trouble with air leaks through cracks caused by temperature expansion, and, even when made of reinforced concrete there was not much improvement with any reasonable reinforcement.

In the flues at Bevans an attempt has been made to overcome these difficulties by hollow wall reinforced concrete construction, and so far this has proved quite successful. It will, however, be some time before a definite verdict can be pronounced. The temperature to be handled is about 400 deg. Fahr., but may go up to 600 deg. Fahr.

The design is shown on *Fig.* 14 from which it will be seen that the walls consist of two plastered slabs 1¼ in. thick with an air space between. The framework is made up of angle or tee bar, to which are clipped 1-in. diameter mild steel bars at about 2 ft. 6 in. pitch, and on both sides of these bars "Trussit" is wired and plastered. The effect of this is to leave an air space equal to the diameter of the round bar between the two plastered slabs.

The plaster on the inside or hot side of the flue was composed of 1 part of Portland cement to 1 of ground fire-bricks, and on the outside 1 part of Portland cement to 2 parts of sand. The theory of the construction is that the inside plaster takes the brunt of the heat, and probably cracks, but the outside plaster and main framing remain comparatively cool.

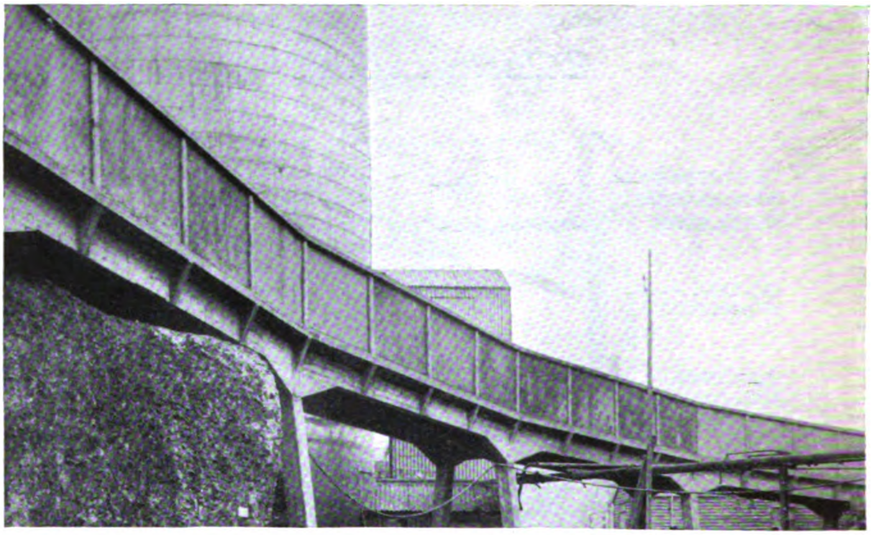


Fig. 16.—Reinforced Concrete Bridge.

Another type of flue to handle gases the temperature of which does not go above 300 deg. Fahr. is shown at *Fig.* 15. In this case a light angle framework supports "Trussit" or similar metal lath, which is plastered on both sides to a total thickness of 2½ in. or 3 in. with sand-and-cement mortar, about 2 to 1.

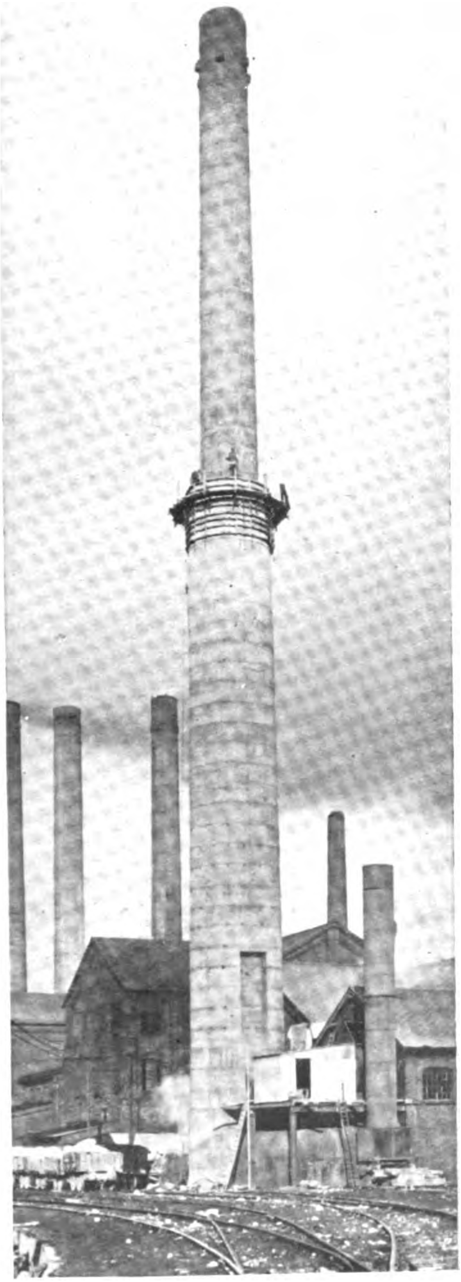
Novel Method of Chimney Reconstruction.

It often happens that an existing chimney becomes too small to deal with increasing boiler plant and it is necessary either to build an additional chimney or a chimney large enough to meet the requirements, after the erection of which the old chimney can be demolished. This is simple where the necessary space is available, but it is often found that the only room for the new chimney is where the old one stands, and the problem then becomes more difficult. It is essential to prevent the stopping of the boiler plant, and also the cost must be taken into consideration.

The photograph shows how the problem has been solved in the case of a 200-ft. chimney at West Thurrock. The chimney is circular, and it was found that the area of the opening was about 50 per cent. too small, which meant that the diameter ought to be increased by about 1 ft. 10 in. There was no site available for building an additional chimney, and the question was how to solve the problem without interfering with the working of the boilers. It was finally decided to erect a new reinforced concrete chimney round the existing chimney, which latter will then be demolished inside the new chimney.

The existing chimney was built in reinforced concrete, and it was found that the existing foundation would be sufficient to carry the new chimney, the only difficulty being to get a proper connection between the foundation and the new shell. The difficulty was overcome in the following manner.

A new foundation was concreted on top of the existing. In order to get proper connection, a tunnel was made under the existing flue and a heavy ring of reinforcement placed in position. This new foundation is not able to take the full load from the new chimney, but part of this load must be carried directly to the old foundation. The existing chimney has a taper of 1·25 per cent., and thus the diameter at the bottom is ample for the new requirements. It was then decided to concrete against the existing chimney on the lower 16 ft., and not demolish this part of the old chimney. In other words, the new chimney is partly fixed to the existing on the lower 16 ft., and through this part the stresses are carried directly to the old foundation.



Chimney at West Thurrock.

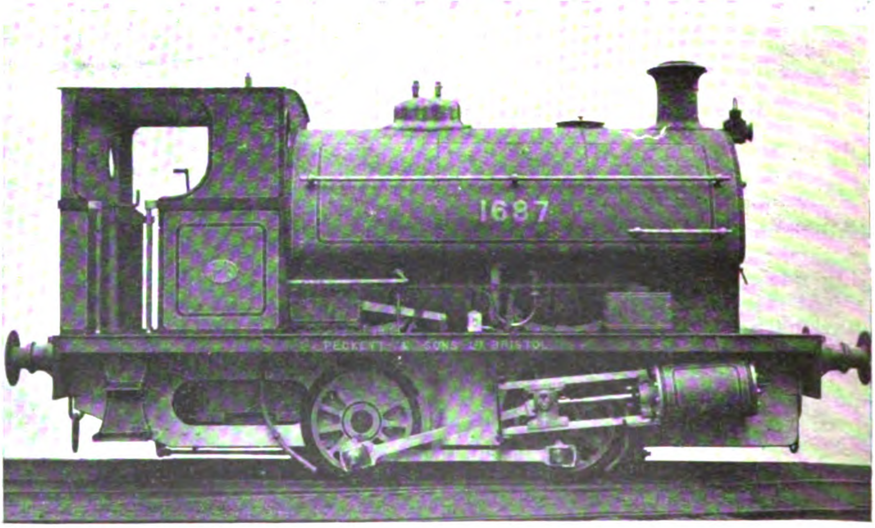
The actual construction of the chimney presented several difficulties, which have been overcome, and the chimney is growing at the rate of 3 ft. 4 in. a day. As will be noticed from the photograph, the work is being carried out entirely without the use of scaffolding, a working platform being fixed to the forms by means of steel brackets. The outer forms consist of three belts, each 3 ft. 4 in. high. The inner forms consist of one belt only, as it would be impossible to shift any lower form belt past higher belts, on account of the existing chimney being too near the forms. It is essential that the inner forms do not touch the existing chimney during construction, as the movements due to wind pressure would prevent a proper hardening of the concrete and bring the forms out of line.

As the work is progressing at the rate of one belt a day, rapid-hardening Portland cement is being employed throughout the work, and has given excellent results, both with regard to strength and appearance of the finished work. The gauging used is 1 part cement to 1½ parts sand to 2½ parts shingle.

The work was designed and is being carried out by the Anglo-Danish Concrete Construction Co., Ltd., of 7–8, Norfolk Street, W.C.2.

Cement Works Locomotives.

We illustrate herewith the type of locomotive supplied by Messrs. Peckett & Sons, Ltd., of Bristol, at Bevans Works of the Associated Portland Cement Manufacturers, Ltd. The specification is as follows: Diameter of cylinders, 14 in.; length of stroke, 22 in.; diameter of wheels, 3 ft. 2½ in.; number of wheels coupled, 4; wheel base, 5 ft. 6 in.; number of brass tubes, 124; diameter of brass tubes, 1¾ in.; copper fire box, ½ in. and ¾ in. thick; capacity of tank, 920 gallons; capacity of coal bunker, 10 cwt.; gauge, 4 ft. 8½ in.; weight loaded, 29 tons.

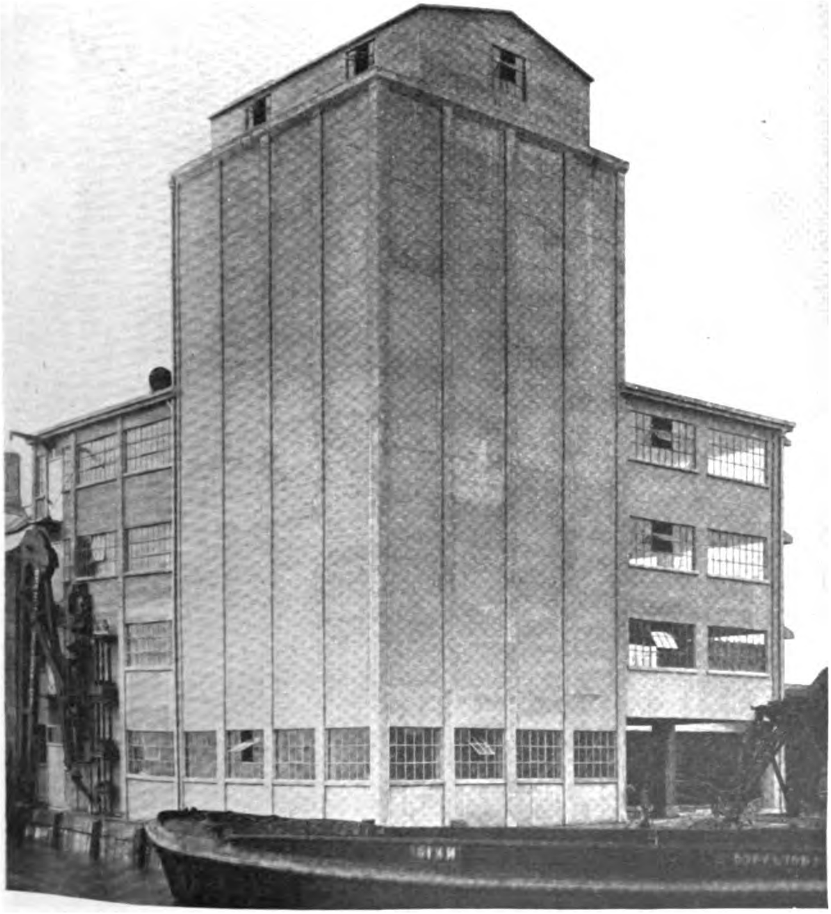


Locomotive for Bevans Cement Works.

Reinforced Concrete Grain Silos and Warehouse at Erith.

A NOTABLE addition to their riverside premises at Erith (Kent) has recently been completed by Messrs. Cannon & Gaze, Ltd. The structure consists of two portions—a battery of silos surmounted by a conveyor house, and a four-story building for use as a warehouse and mill. For convenience in bolting down machinery and cutting holes for chutes, the flooring in the upper floors of the warehouse and mill is of timber supported on steel secondary joists, which in turn are carried on reinforced concrete main beams. The rest of the structure is constructed in reinforced concrete.

The whole of the building, including the ground floor, is carried on seventy-four reinforced concrete piles 14 in. by 14 in. in section ranging from 25 ft. to 45 ft. in length. The reinforced concrete columns which stand next to the



Reinforced Concrete Grain Elevators and Warehouse at Erith.

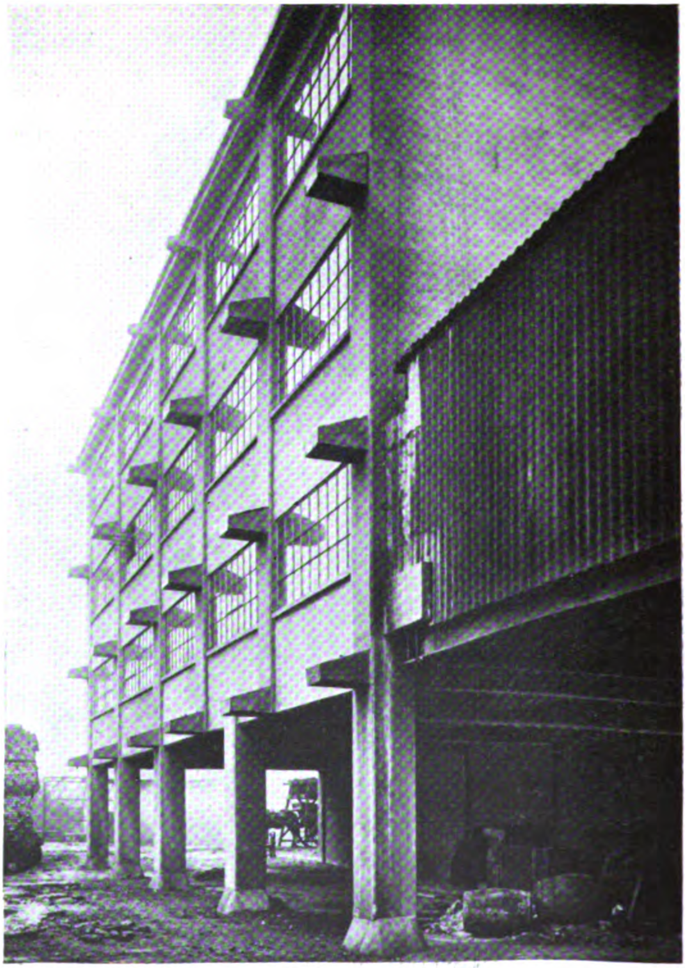
existing gable wall are carried on the outer ends of heavy cantilever footing beams, as may be seen from the longitudinal section. Provision has been made for carrying a future extension on the land side of the building.

Following modern practice, the silos are divided into sixteen small bins 7 ft. square and 50 ft. deep.

A new wall was formed along the river front of the building by driving a row of reinforced concrete sheet piles 25 ft. long in front of the existing timber sheeting. A feature of the grain-handling plant is the swivelling barge elevator which, as can be seen from the photograph, is bolted to the river face of the mill building.

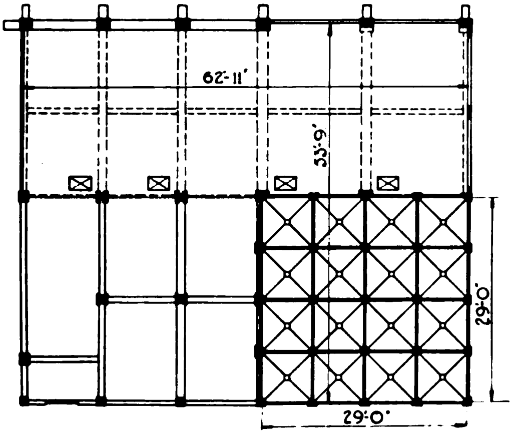
The test piles were constructed in aluminous cement, rapid-hardening Portland cement being used for most of the other piles and for a considerable part of the superstructure. Steel "Blawforms" were used for the internal walls of the silos.

The contract for the complete building, including the supply and erection of the plant, was placed with Messrs. Thomas Robinson & Son, Ltd., Rochdale.

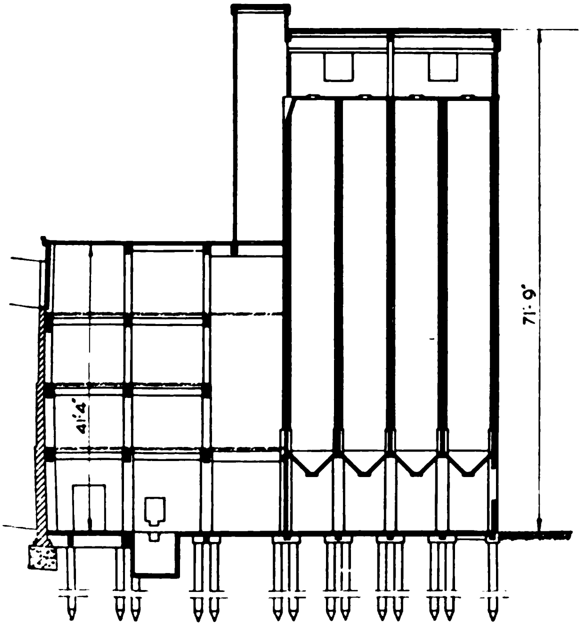


Reinforced Concrete Grain Silos at Erith.

The reinforced concrete work was designed and constructed by Messrs. Peter Lind & Co., of Westminster, while Sir E. O. Williams, K.B.E., M.Inst.C.E., acted as supervising engineer for the owners.



Sectional Plan.



Longitudinal Section.

The Theory of Bending.

THE following is an abstract of a paper entitled "A New Theory of Bending" by Mr. Arthur C. Vivian, B.Sc., Assoc. M.Inst.C.E. about to be published by the Institution of Civil Engineers:—

The paper describes a theory of stress-distribution on a transverse section of a rectangular beam when bent. The beam is assumed to be subjected to pure bending only, up to the point of fracture. The author points out that the usual theory of a straight-line distribution of stress is only substantiated by practical tests over very limited ranges of stress, and advances a general formula which embraces the straight-line theory as a particular case.

The connection is illustrated between the stress-distribution across a plane section of a bent beam and the stress-strain diagram of an elastic material, and the author questions the definition of an elastic material as one which has a straight stress-strain graph. He surmises that the true test of an elastic material is that its stress-strain graph follows a smooth curve. The term "limit of proportionality" is cited to support the contention that the straight-line theory is suspect.

Three postulates are stated upon which the theory is based. An equation is shown to satisfy the three postulates. This equation possesses remarkable properties, certain of which are set out; and it contains a function termed the "form factor" of a material. This term is shown to express some physical property which causes different materials to have different ultimate moments of resistance, even though of the same cross section, and apart from their different ultimate tensile or compressive strengths.

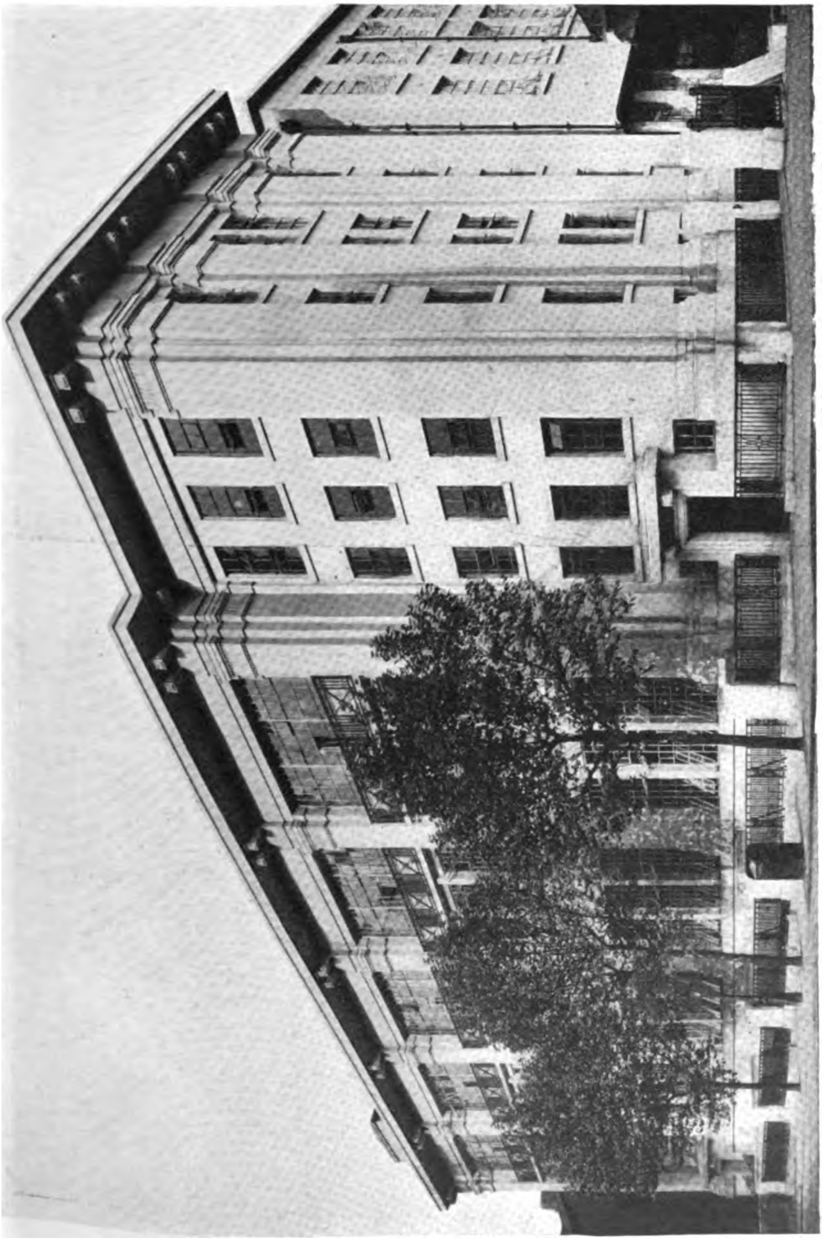
The paper illustrates how, by assigning a definite numerical value of form factor, the ultimate moment of resistance of a rectangular section can be deduced, and it provides a method of determining the form factor practically. It is also shown how the general equation may be made to represent the well-known relation between extreme fibre stress and section modulus, which is based on the straight-line theory.

The author next proceeds to apply the theory to intermediate ranges of stress. An approximation is resorted to, and a graph is given, so that for any required limits of design stress an equivalent form factor may be selected and used in the general equation of bending. Thus, when the theory is put into practice and applied to the design of beams, the numerical value of the form factor of the material will be required in addition to its ultimate tensile or compressive strength.

Mathematical proofs are given of the statements advanced, and a method of determining the modulus of elasticity of a material is described.

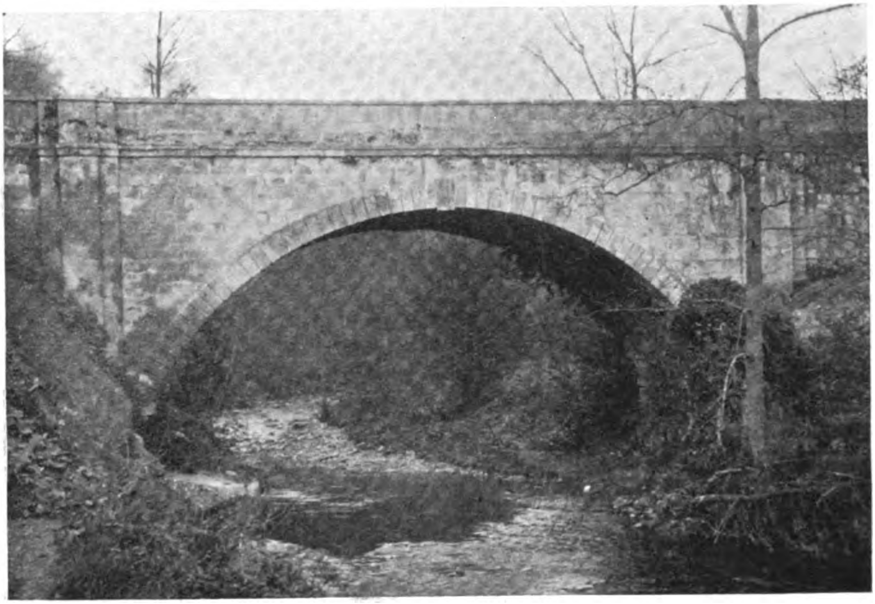
New Letter Office, Mount Pleasant.

THE new Letter Office for the General Post Office at Mount Pleasant stands on the site of the old Coldbath Prison, and was opened for use in July last. The building is entirely of reinforced concrete, plastered with white cement externally and Keene's cement internally. The reinforcement, which was designed by H.M. Office of Works, consisted of mild steel round rods made up to 1½ in. diameters, many of the bars being over 50 ft. long. The concrete was made of ¾-in. ballast and sand from the river Lea. The architect is Mr. A. R. Myers, A.R.I.B.A., of H.M. Office of Works, and the contractors Messrs. Galbraith Bros., Ltd., of 71, Waterloo Street, S.E.5.

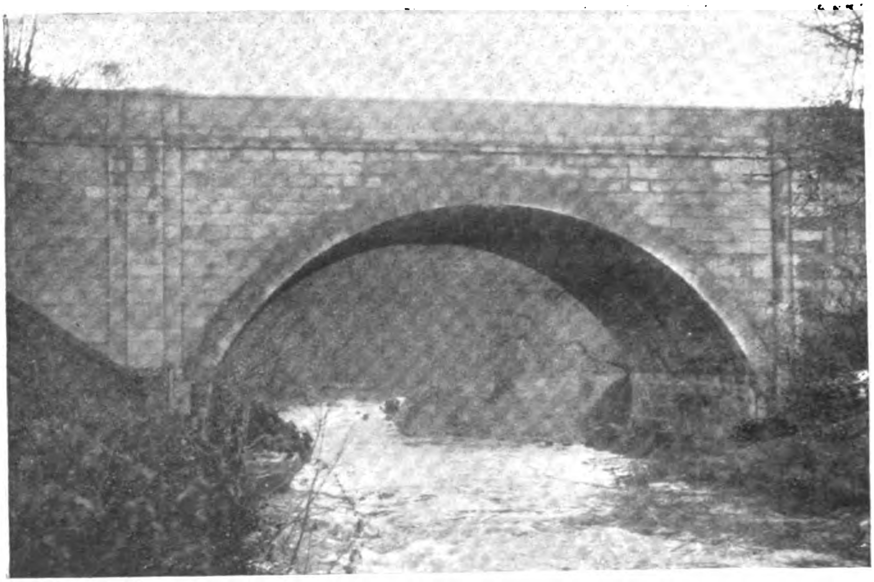


[*Mr. A. R. Myers, A.R.I.B.A., Architect.*

New Letter Office at Mount Pleasant for the General Post Office. (*See p.* 34.)



Before Widening.



After Widening.

Reconstruction of Chirk Bridge. (*See p.* 37.)

Bridge in Coloured Concrete.

CHIRK Bridge, situated in Shropshire on the borders of that county and Denbighshire on the London–Holyhead Main Trunk Road, spans the river Ceiriog. It was built by Thomas Telford about a century ago, and is a very fine example of that eminent engineer's work.

Under the widening scheme of the London-Holyhead Main Road it was found that it was only necessary to widen the bridge, and this was done by the construction of a new bridge alongside, 30 ft. in width, in reinforced concrete (Hennebique system). The large reinforced concrete arch ribs of 50-ft. span spring from mass concrete foundations and abutments, which in turn support the beam and decking forming the roadway, the soffit of the arch being of light reinforced concrete construction so as to carry through the effect of the old bridge, the space between the flat road decking and the arch being hollow.

In order to preserve the appearance of the old masonry bridge, it was decided that the facework of the new bridge should harmonise with the old. A combination of coloured *in situ* work for the arch and coloured concrete blocks for the spandrils was decided upon, and as the old bridge was built of sandstone and mellowed with age, great care was necessary to make a faithful copy. Many experiments were made to obtain the nearest approach to the existing work; no less than two dozen sample colours of a greenish-yellow brown were made, and after careful consideration of these samples on the site against the existing work and natural surroundings, the desired shade was chosen. The proportions of colouring matter were carefully recorded and rigidly adhered to throughout the construction.

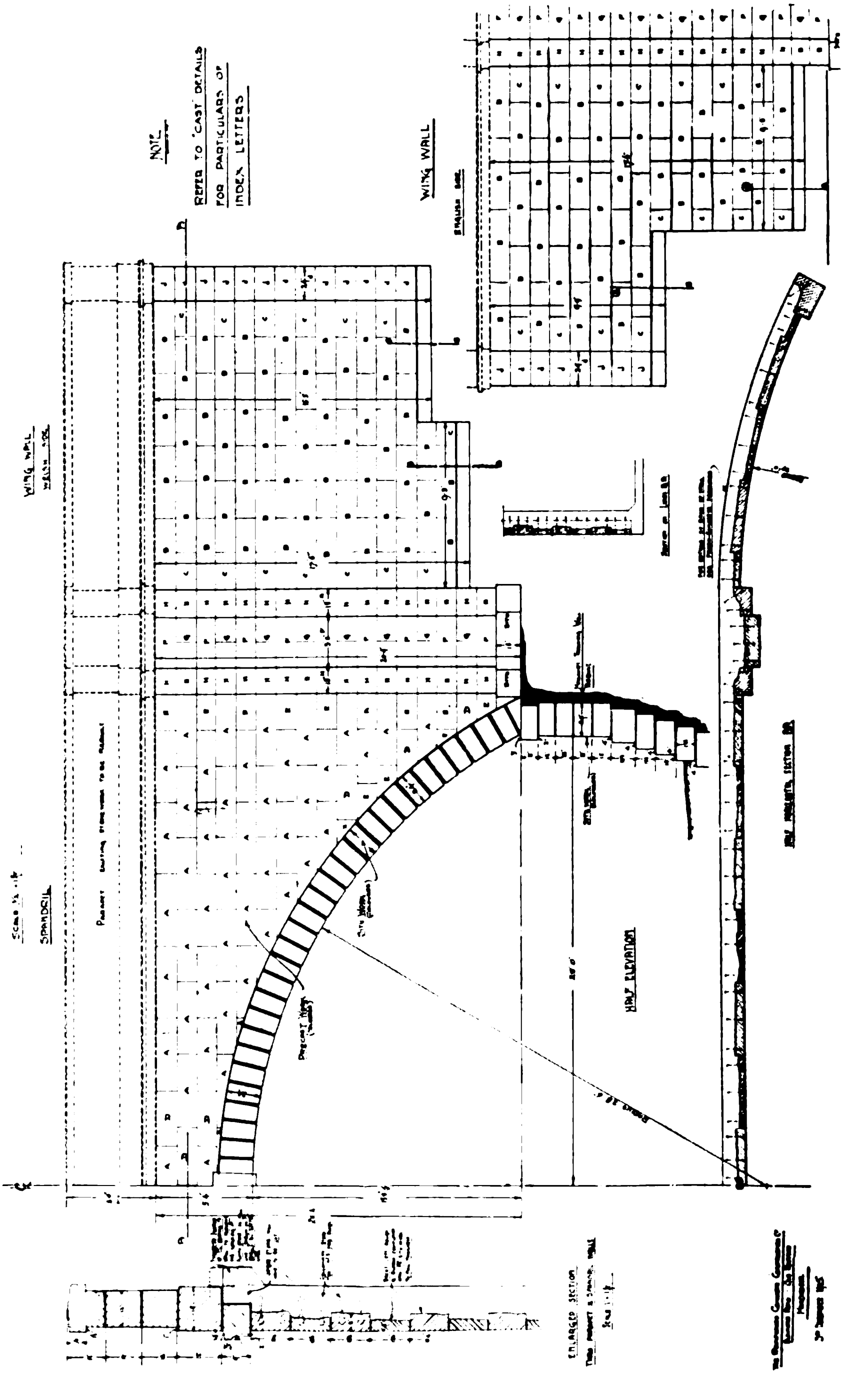
The soffit of the arch, arch beams, and abutments are *in situ*. These portions of the bridge had to match the boasted ashlar of the existing bridge wall. The piers and spandrils are of pre-cast concrete blocks averaging 9 in. in thickness to match the old tooled face and the fine tooled border edging to each stone. For this purpose plaster casts were made of the existing stones and a series of moulds made for the reproduction to suit the new coursing (the plan on p. 38 shows how this was arranged). The old stone parapet and string-course was, on completion of the new wall, built over the new arch. So carefully has the reproduction work in concrete been carried out that it is difficult to tell which is the old stone work reset and which is the reproduced work in coloured concrete.

The photographs of the old bridge taken before widening operations commenced and of the bridge as it now appears widened show the completeness of the reproduction of the old work. The drawing on p. 38 shows how the coursing of the pre-cast concrete blocks was arranged, and the method of bonding these blocks into the reinforced concrete *in situ* backing. It also shows the coloured voussoirs, arch, and abutment wall *in situ* work, as well as that portion of the old stone parapet and cornice which were rebuilt in the new position.

The work has been carried out for Mr. W. H. Butler, County Engineer for the Shropshire County Council, by the Reinforced Concrete Construction Co., of Manchester, who were also responsible for the coloured bridge at Dalemain illustrated and described in our issue for December, 1925.

Concrete Silos in Norfolk.

IN our last number we illustrated two reinforced concrete silos in Norfolk. Unfortunately we omitted to mention that these structures were both erected by Messrs. May, Gurney & Co., Ltd., of Trowse, Norwich, to whom we were indebted for the photographs.

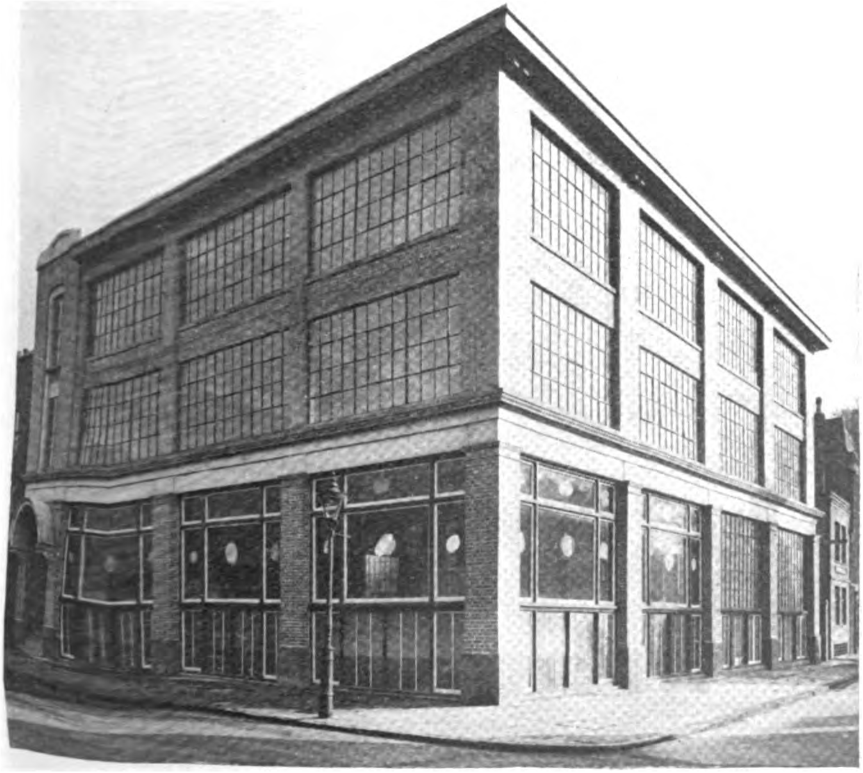


Pre-cast Details and Lay-out of Reconstruction of Chirk Bridge. (*See p.* 37.)

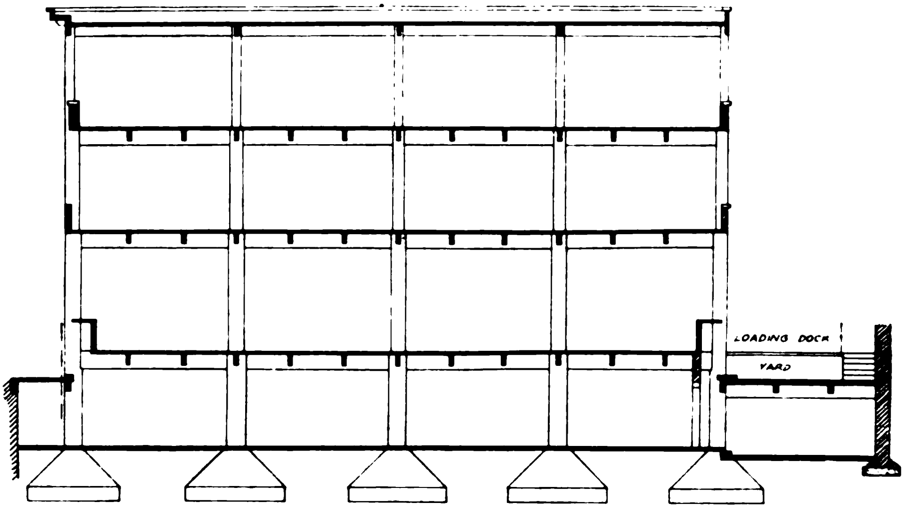
Reinforced Concrete Factory at Islington.

THE new factory and warehouse premises erected by Messrs. Commercial Structures, Ltd., at Spencer Street, Islington, is a good example of a concrete frame building, combining efficiency with a pleasing appearance. The building, which is planned as a " daylight " factory, makes use of all the permissible window space obtainable under the L.C.C. regulations, with the result that a light and airy structure has been produced in which even the ground floor is well lighted. *Fig.* 1 shows how a pleasing architectural effect has been obtained with the use of straight lines which are easy to form in the concrete moulding. It will be noticed that the whiteness of the building is relieved by the introduction of narrow red brick panels along the lintels and by facing the ground floor piers and entrance section with brick.

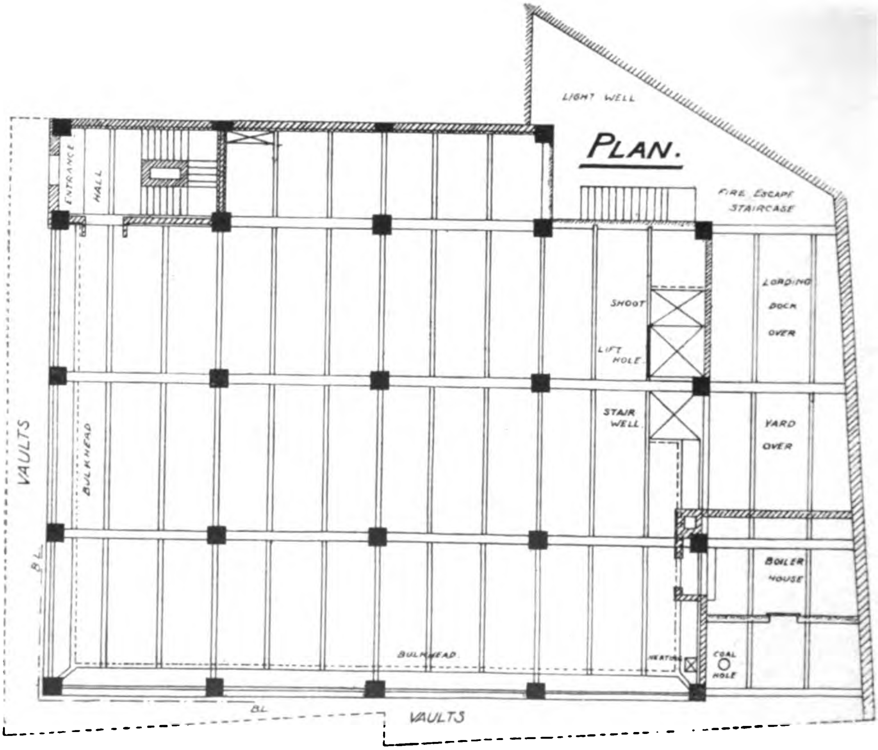
The section and plan of the reinforced concrete construction shown on p. 40 give an idea of the spaciousness of the interior. The building is divided into bays of 18 ft., which is a useful column spacing for factory and warehouse purposes and by subdividing the bays into three floor panels a light floor is obtained in spite of the warehouse superload for which it is calculated. Provision has been made for admitting as much light as possible into the basement by means of a reinforced concrete bulkhead at street level. The basement extends under the footpaths and the yard and under the loading dock; the latter is on the same level as the ground floor and 3 ft. 6 in. higher than



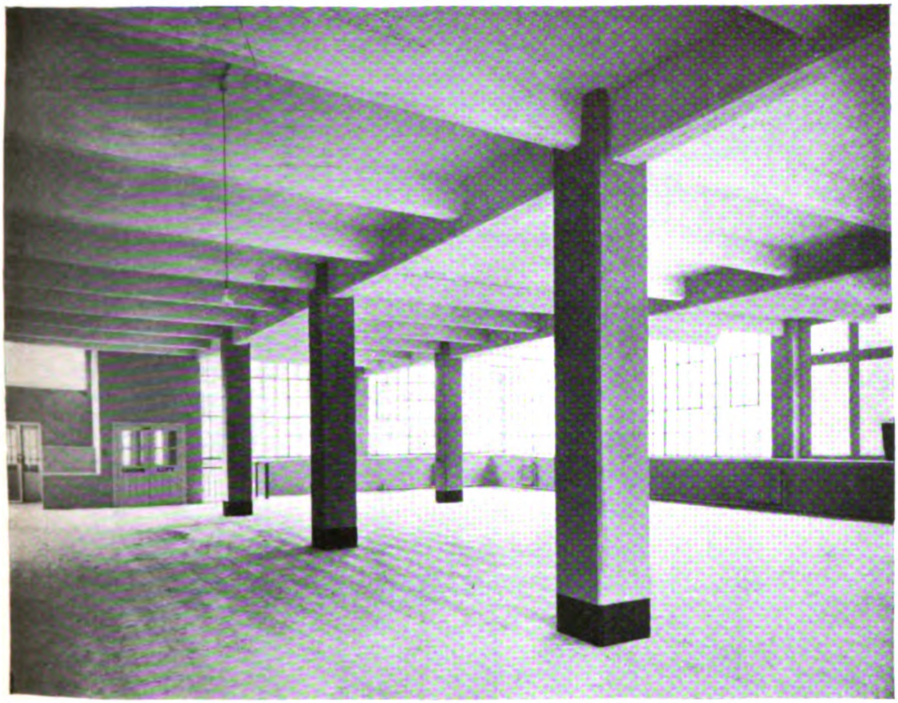
Reinforced Concrete Factory at Islington.



LONGITUDINAL SECTION.



Reinforced Concrete Factory at Islington.



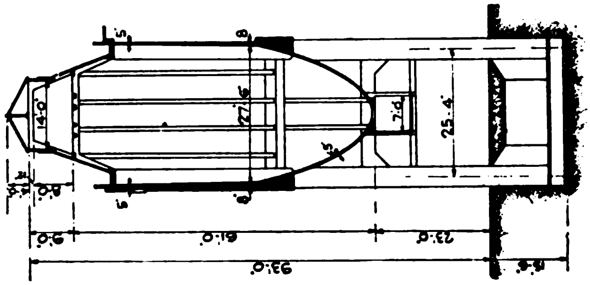
Reinforced Concrete Factory at Islington.

the street level, and communicates with the basement through a chute and also by means of a lift which runs through all the floors. The internal view above shows the ground floor communicating with the basement by a stairway on the right of the lift, while to the left are seen the chute and doors opening directly on to the loading dock. At the top of the windows the beams are underslung from the lintels, so as to avoid any light obstruction from the latter. On the upper floors sleeves are left in the beams as a provision for carrying machinery and fittings.

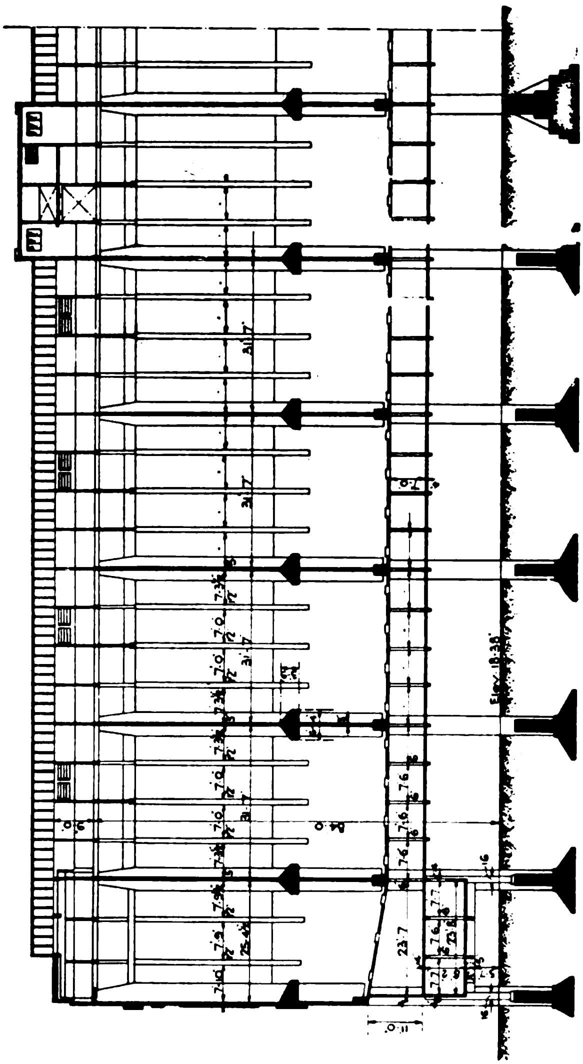
The general building work was carried out by Messrs. Commercial Structures, Ltd., on whose instructions Mr. R. N. Stroyer, M.I.Mech.E., of Abbey House, Victoria Street, S.W.1, prepared the design for the reinforced concrete work, which was executed by Mr. A. E. Frost, of Wood Green.

Binding Cases.

Cases for binding Vol. XXI, 1926, of "Concrete and Constructional Engineering" are now ready. The cases are strongly made, cloth covered, and lettered in gold on the side and spine with the title and date. They may be had from Concrete Publications, Limited, 20 Dartmouth Street, Westminster, S.W.1, price 3*s*. each, plus 2*d*. for postage.



Cross Section.



Sectional Elevation.

10,000-Ton Coal Bunker at Greenwich Power Station. *(See p. 43.)*

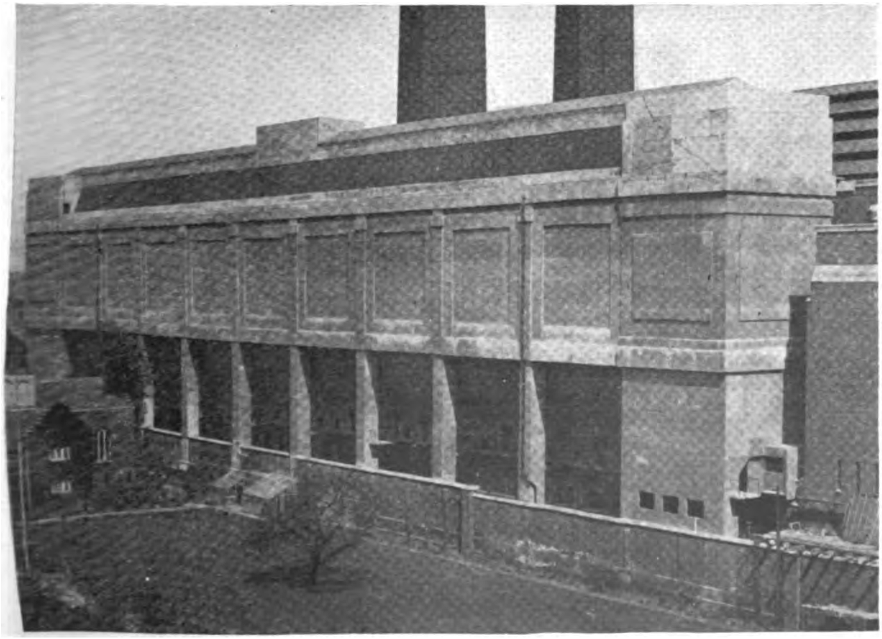
10,000-Ton Coal Bunker at Greenwich.

THE coal bunker illustrated herewith has recently been completed for the London County Council at the Greenwich power station which supplies power for the L.C.C. Tramways. It has a capacity of 10,000 tons. The overall length is 340 ft.; the height 100 ft.; and the width 30 ft. The bunker is divided into eleven separate compartments which can be loaded or emptied independently.

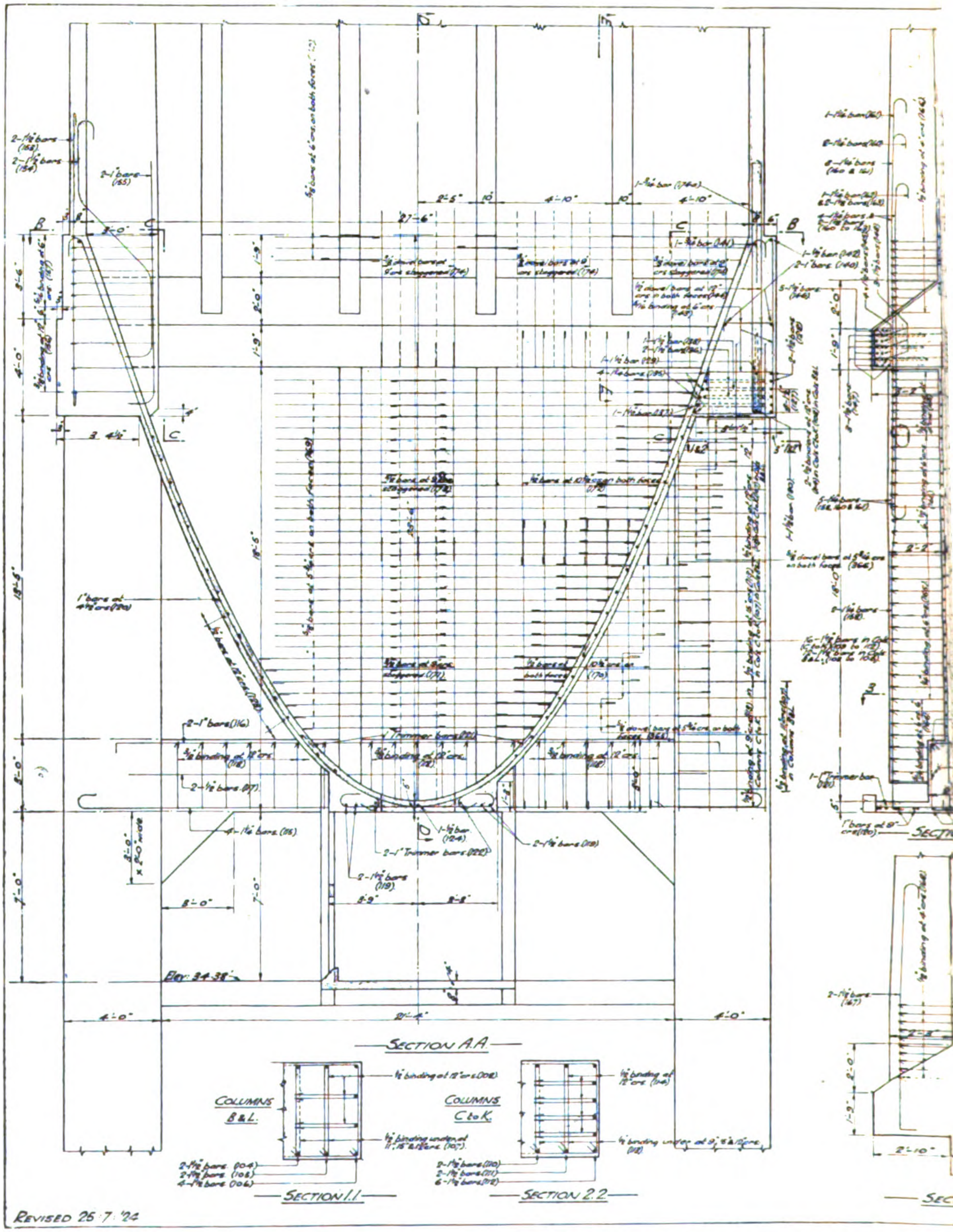
The coal handling plant consists of a series of conveyors capable of transferring coal from boats or barges in the river to a conveyor running along the top of the bunkers; it is also capable of receiving the coal from the hoppers and conveying it back to bunkers in the power house which feed the mechanical stokers on the boilers.

The work was put out to tender among firms specialising in reinforced concrete design and [illegible] of Messrs. Industrial Constructions, Ltd., being accepted. The considerations which influenced the Council in accepting this design were as follows: (1) The positions chosen for the large concrete columns, which had to penetrate through workshops, mess rooms, lavatories, and other additions to the main power station building. (2) That a clear space was required for the coal in each of the bunkers without the interference of cross ties. On account of the very large dimensions of the bunkers, it became difficult to devise means to take the heavy pressures without introducing ties near the bottom of the bunkers; this difficulty was overcome by making the bottom of the bunkers parabolic in shape, the thrusts at the top of the parabola being taken by the heavy mass of concrete reinforced as a beam spanning between column and column. The parabola was chosen because of its simplicity in construction and the fact that it eliminates very largely the secondary stresses and carries the whole of the load and pressure by a skeleton of tensile reinforcement clothed with 5 in. of concrete. (3) Architectural treatment of the elevation.

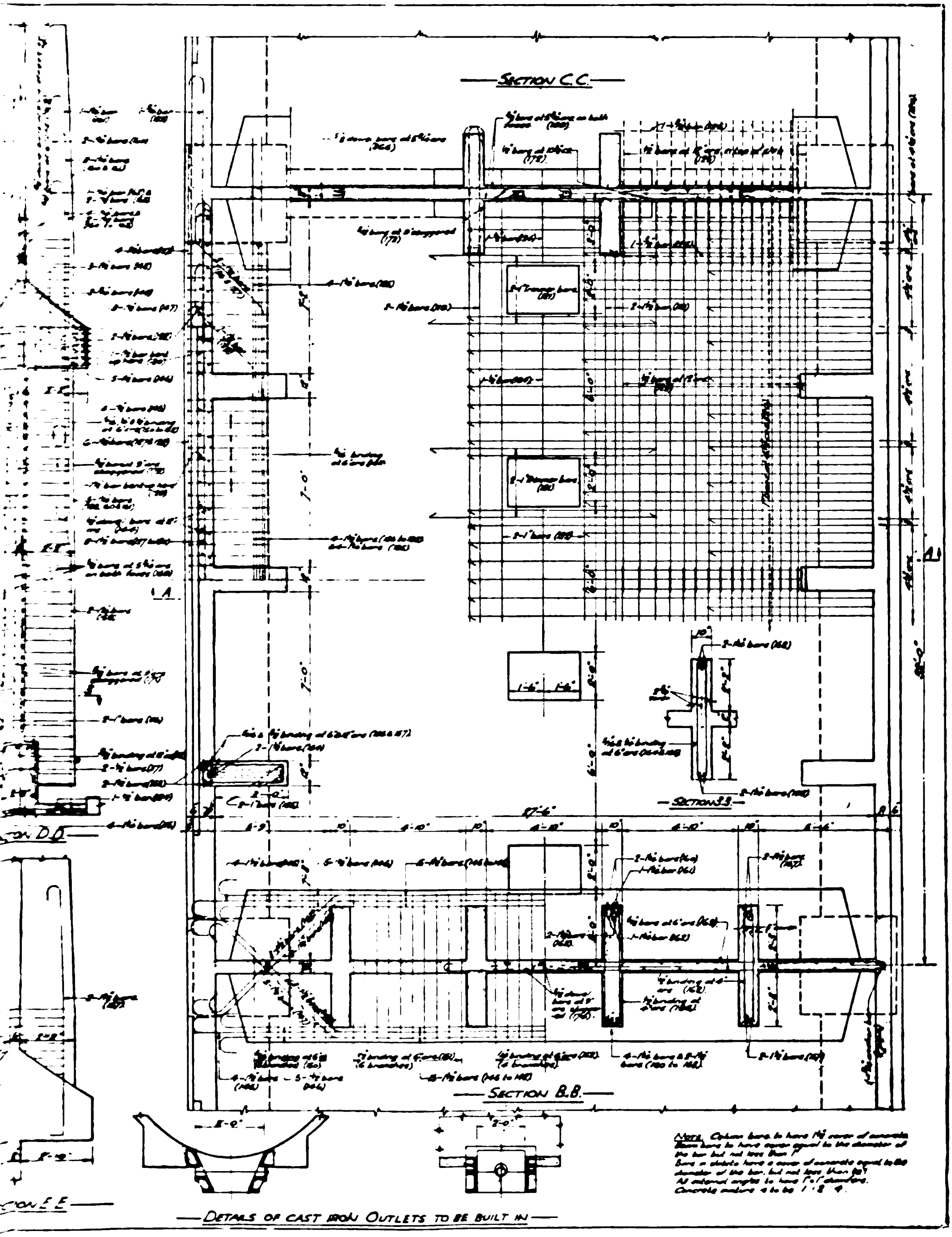
To construct a bunker of this shape and magnitude is to a reinforced concrete



10,000-Ton Coal Bunker at Greenwich.



10,000-TON COAL BUNKER AT


SECTION C.C.
SECTION B.B.
SECTION 3.3.
SECTION D.D.
SECTION E.E.
A
A
27'-6"
DETAILS OF CAST IRON OUTLETS TO BE BUILT IN
Note. Column bars to have 1½" cover of concrete. Beam bars to have cover equal to the diameter of the bar but not less than 1".
Bars in slabs to have a cover of concrete equal to the diameter of the bar, but not less than ½".
All external angles to have 1"×1" chamfers.
Concrete mixture is to be 1 : 2 : 4.

GREENWICH POWER STATION.

specialist a straightforward job, but when the foundations and columns have to be constructed underneath and in workshops, mess rooms, lavatories, and suchlike buildings without interfering with the use of such offices the designer is faced with a very complex problem. It was this, and the insistence of the L.C.C. to have a bunker without internal obstructions to the flow of coal, that constituted the design of the structure a very difficult problem. It would have been comparatively easy to find positions for the columns and foundation beams if an unsymmetrical design had been adopted and the columns put at varying distances apart to miss the various obstacles met with, but this would have been objectionable from an æsthetic point of view and would have increased the cost of the work. To overcome the difficulty it was found that by spacing the columns at 32-ft. centres and making the end bays about 25 ft., a suitable arrangement as far as the existing work was concerned could be secured. This spacing was adopted, and the columns placed as far apart as possible in the cross-section in order to add to the stability of the structure.

The next problem that had to be faced was the design of the bunkers in order to avoid any internal obstruction to the flow of coal. In a small structure this is, of course, comparatively easy, but where the dimensions of the bunker are such as in the case under consideration, namely 27 ft. wide, 31 ft. 7 in. long, and 61 ft. deep, the problem is different. The pressure on the walls is taken by a series of vertical beams which enable the thicknesses of the walls to be kept within reasonable limits. Ordinary slab and beam construction, however, would have made the bottom of the bunker very heavy and costly to construct, and it was therefore decided to make the bottom of the bunker a parabola and to provide sufficient steel reinforcement to take the whole of the tension due to the weight and the pressure, and to employ the concrete merely as a covering to the steel reinforcement. This has proved under test to be quite satisfactory, and has entirely justified the assumptions of the designers. Any alterations in the shape of the parabola due to variations of loading have not caused any perceptible cracks in the concrete.

Mr. G. Topham Forrest, Architect to the London County Council, under whose instructions the bunker was built, naturally desired the structure to be of good proportion and appearance, and the designers were anxious to develop the constructional features of the building. The engineers therefore kept in close touch with Mr. H. R. Gardner, F.R.I.B.A., an architect with considerable experience in reinforced concrete elevations, with the result shown in the photograph.

The reinforced concrete throughout was composed of 4 parts of crushed ballast to 2 parts of sand to 1 part of Portland cement, with the exception of the columns which were constructed with 2 : 1 : 1 mix. The reinforcement consisted of mild steel smooth bars. Complete calculations and working drawings were submitted to the L.C.C. for approval.

Cement Plant by Edgar Allen & Co., Ltd.

During 1926 Messrs. Edgar Allen & Co., Ltd., of Imperial Steel Works, Sheffield, have manufactured the following plants for the production of Portland Cement. Complete two-unit plant (capacity 130,000 tons per annum) for the Dunstable Portland Cement Co., Ltd. ; complete single-unit plant (capacity, 35,000 tons per annum) for the Barnstone Cement Co., Ltd. ; complete two-unit plant (capacity 110,000 tons per annum) for the Standard Portland Cement Co., Ltd., New South Wales ; 30,000 ton unit for the Sulphide Corporation, Ltd., New South Wales ; lime-burning plant for the Dhrangadhra State Chemical Works, India.

Dolphins with Loose Filling.

By OVE ARUP.

THE main difficulty in the construction of marine and harbour works is the carrying out of the subaqueous construction, which often involves the erection of large cofferdams, heavy pumping expenses, etc. It is natural, therefore, that the aim of designers should have been directed towards the abolition of subaqueous work wherever possible, and this is usually achieved by means of driving piles.

The introduction of reinforced concrete piles has been a great step forward in this respect, by making it possible to construct even the heaviest quay walls without cofferdams and without any tide-work of importance, when the site is suitable for pile driving.

In the case of jetties and other structures which are built out into the water, piling is also the usual method employed. As long as the depth of water and the size of the ships to be accommodated are not excessive, this method is quite satisfactory, especially if raking piles are introduced. These enable the structure to take up the horizontal forces acting upon it in direct compression and tension, and thus considerably increase the kinetic energy which the structure can absorb without being overstressed. When, however, the depth of water and the size of vessels to be berthed increase, it is necessary to provide structures of a much heavier type in order to resist the impact from the vessels. Much can be done by providing a heavy and rigid superstructure which distributes the forces acting upon it over the whole number of supporting piles, but if it is a case of providing berthing accommodation for, say, vessels of 10,000 to 20,000 tons, a rough calculation will soon show that the ordinary type of piled construction is quite inadequate if velocities of up to 1 ft. per second are reckoned with. In such cases it is essential to provide heavy masses to withstand the impulse forces from the vessels, and sometimes massive concrete structures extending right down to firm ground have been erected at a great expense. If firm ground is found not too far down it may be possible to sink pre-cast reinforced concrete cylinders, or to use caissons which are afterwards filled with concrete or earth-filling, but if, for instance, the bearing strata is covered by a thick layer of mud or similar substance, which is often the case, this solution is hardly possible unless an artificial bed is provided for the caissons by depositing great masses of sand or gravel, a method which in any case will be expensive. It may be of interest, therefore, to see how this difficulty has been overcome in the case of some structures designed and erected by Messrs. Christiani & Nielsen.

The method adopted is that of driving a number of piles close together in a circle, holding them together by means of circular ties, and filling the cylinder thus formed with a suitable filling of stones or gravel. This type of construction combines the advantages of a piled structure, i.e. absence of work under water level, with the advantages of a massive construction, the necessary mass being obtained in the most economical manner by a loose filling. The piles may be of reinforced concrete, steel or timber according to circumstances, and an example of each kind will be described in the following.

The simplest type of this kind of construction is that embodied in a pier built at Nyborg, Denmark, for the Danish Petroleum Co. As will be seen from *Fig.* 1, the general lay-out consists of a solid pier connected to the shore by an approach of reinforced concrete piles, and a dolphin of the type described above. The distance between the pier and the dolphin is arranged so that the ship when berthed is lying alongside both. The depth of water at the dolphin is about 30 ft. The dolphin consists of round timber piles 16 in. in diameter, driven in a circle of 23 ft. diameter. The piles are driven about 20 in. from centre to centre, and are held together by galvanised steel straps at four different levels. The filling consists of stones sufficiently large to be retained by the piles.

The solid pier is constructed of two reinforced concrete sheet walls, anchored together by reinforced concrete capping beams and ties above high-water level, and filled with sand. This kind of construction is a development of the ordinary cofferdam and has the same advantages from the point of view of construction as the circular dolphin with loose filling. It can be appropriately used in a case like this where the depth of water is not excessive and the bottom consists of firm sand and gravel, forming an excellent support for the sheet walls only a few feet below the bottom. But the fact that it would be a rather complicated matter with this type to provide ties below low water level puts a limit to the depth of water, or rather the depth down to firm ground, at which this type of construction can be used with economy. In this respect the circular type of dolphin has a big advantage because of the ease with which it is possible to provide supports for the sheet wall at any level required by lowering circular ties round the piles.

Another structure where dolphins of this kind have been used successfully is the train ferry berth at Harwich, the general lay-out of which is shown in *Fig.* 2. This berth was built in 1924 for Great Eastern Train Ferries, Ltd., and forms the English terminus for the first commercial train ferry between England and the Continent. As will be seen from *Fig.* 2, the berth consists of two piers, 415 and 120 ft. long, which for the greater part of the length follow the line of the vessel. The connection between the permanent way and the ferry is effected by a movable steel bridge which can be lowered

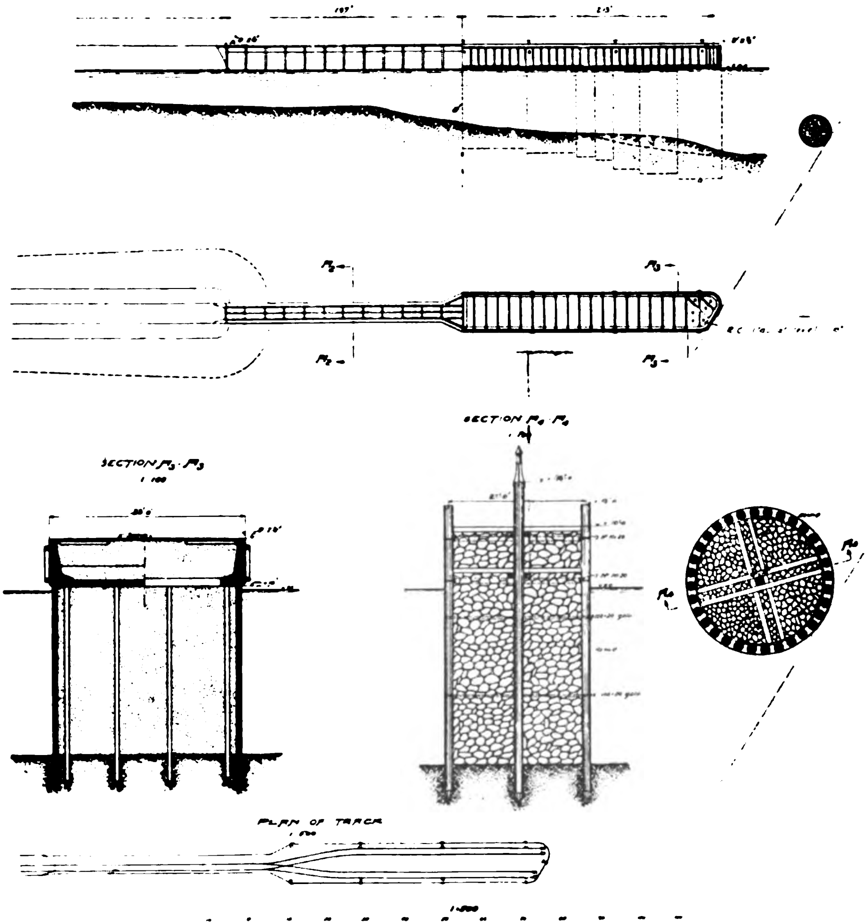


Fig. 1.

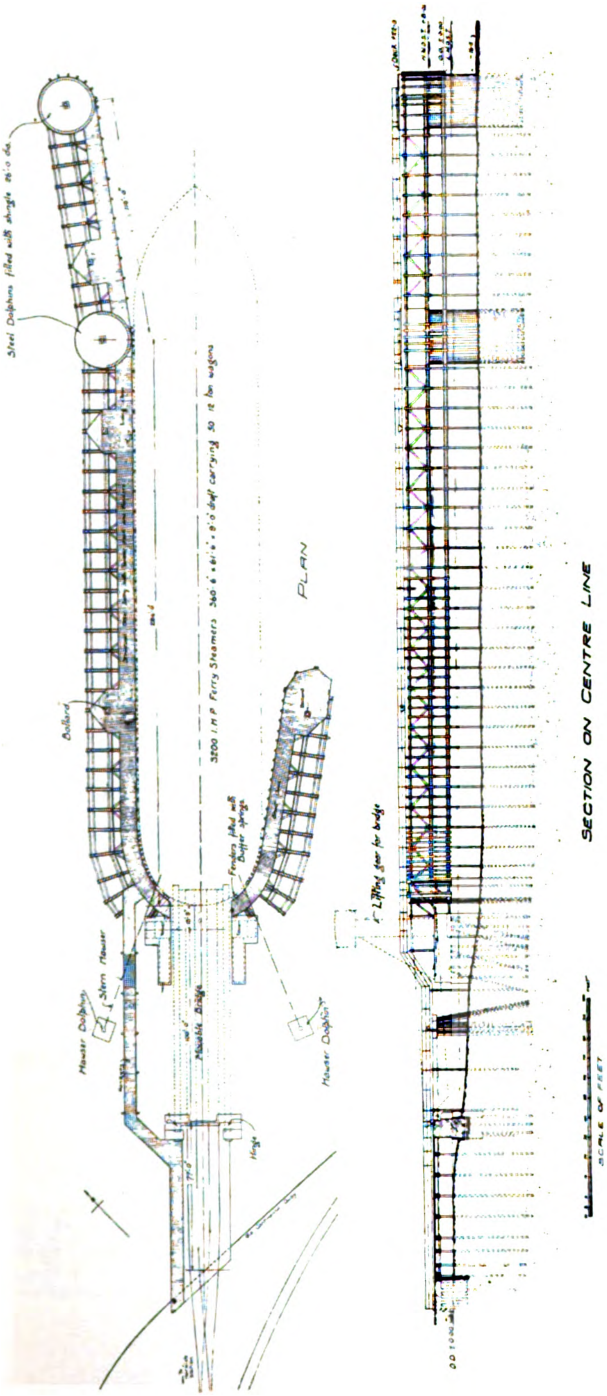

Steel Dolphins filled with shingle 26'0 dia.
3200 I.H.P. Ferry Steamers 360'6 x 61'6 x 9'0 draft carrying 30 12 ton wagons
PLAN
Bollard
Fenders filled with Buffer springs
Stern Mawser
Mawser Dolphin
Mawser Dolphin
Movable Bridge
Hinge
Lifting gear for bridge
SECTION ON CENTRE LINE
SCALE OF FEET

Fig. 2.

down on the vessel when it is in the berth.

In considering what type of construction should be adopted for the various members of the general lay-out, the principle has been followed of concentrating the resisting capacity of the structure in a few important points and to make the rest of the structure as elastic and resilient as possible. The reason for this was partly to effect economy and partly to ensure the final impact between the vessel and the berth being as gentle as possible.

The points which it was considered essential to strengthen as much as possible were the end and the turning point of the long pier and the stern end of the berth, where the final impact had to be taken. At the latter point the necessary resisting capacity had to be combined with a springing effect of the fenders, and strong buffer spring boxes were therefore inserted between the fenders and the rigid

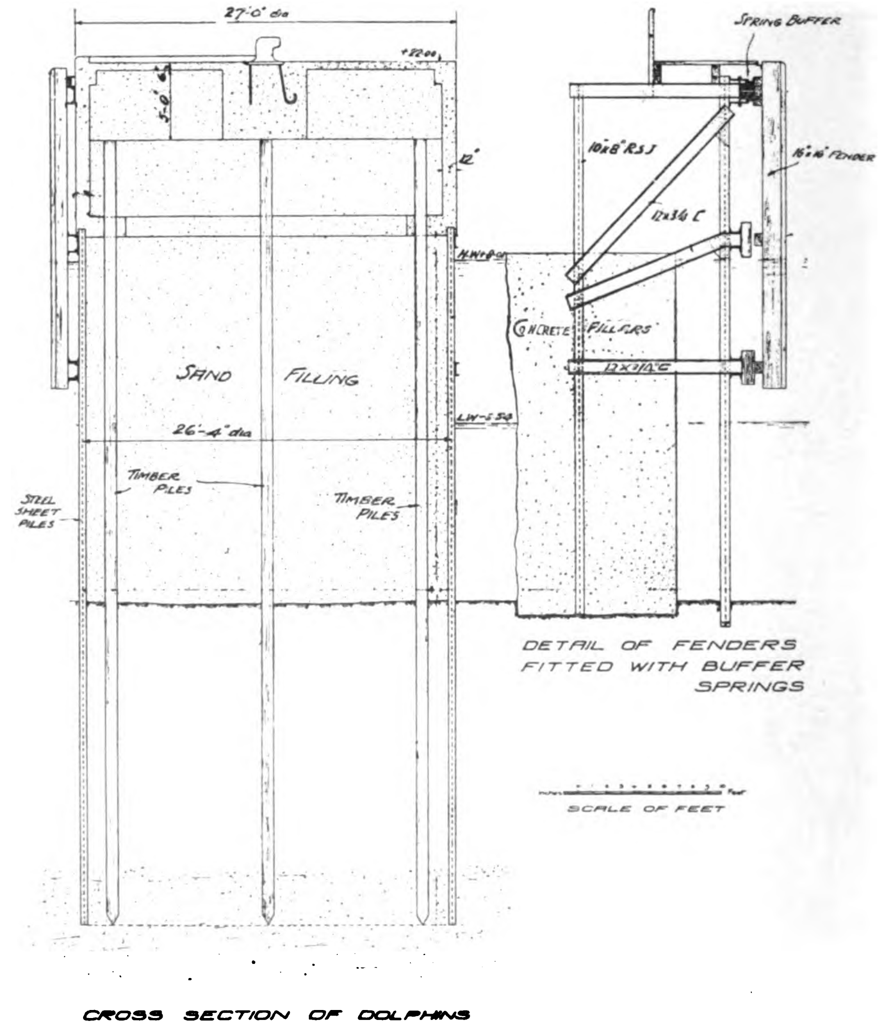


Fig. 3.

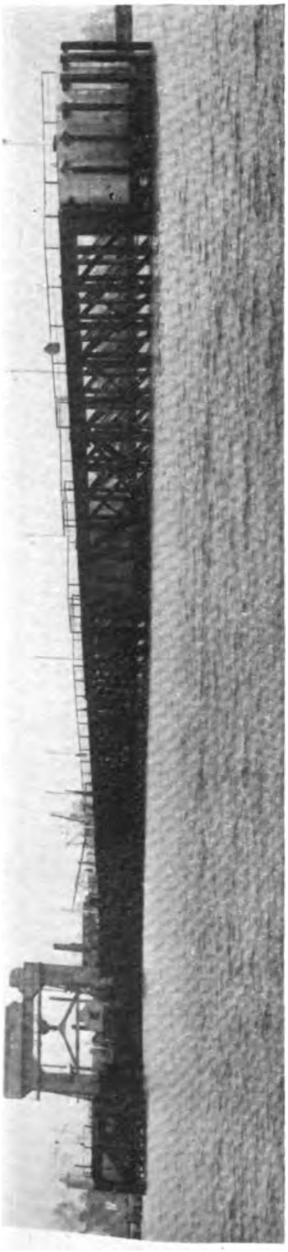


Fig. 4.

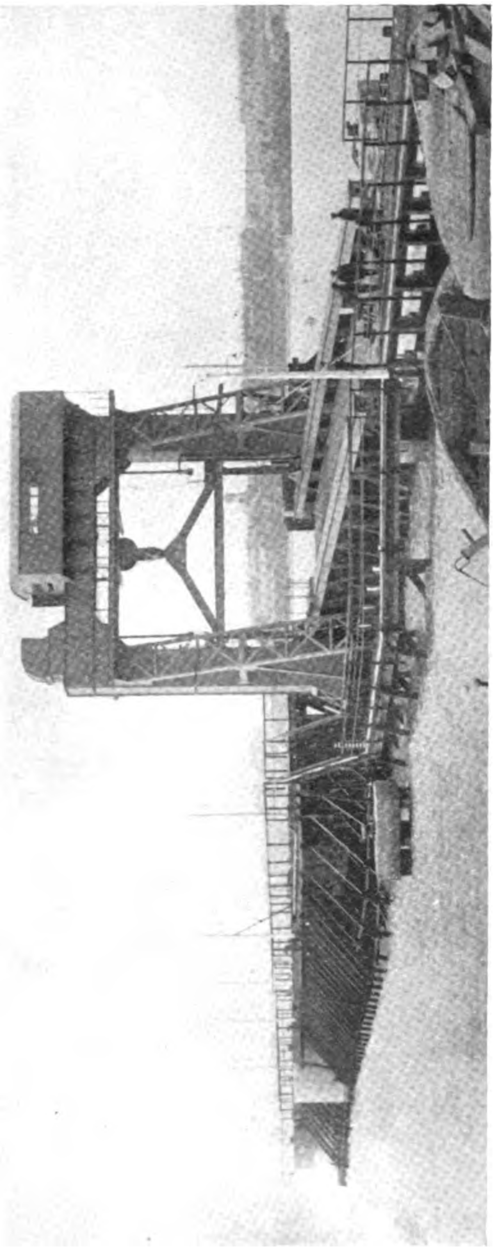


Fig. 5.

structure (*see Fig.* 3). As will be seen from this plan, the rigidity at this point is ensured by the two heavy reinforced concrete piers which support the two steel towers for the bridge, and which are again each supported on 24 timber piles. The concrete at this place is carried to 5 ft. below the sea bottom, and had to be placed inside a sheeting of steel piles and timber through a vertical wooden tube which could be lifted gradually as the concreting proceeded.

At the two other fixed points mentioned above, namely the end and the turning point of the long pier, cylindrical dolphins with loose filling of the type already described were constructed. The diameter of the dolphins is 26 ft. The piles in this case are interlocking steel sheet piles driven side by side. The filling consists of gravel. The piles are held together with R.S. channels, and on top a reinforced concrete wall and decking are provided. The ground consists in its upper formation of mud overlying layers of clay of increasing hardness, and the piles had to be driven down to a considerable depth below bottom.

In driving the sheet piles the greatest care had to be exercised to make it possible to close the circle when the last pile came to be put down. Each pile was controlled as it was driven so that it was kept truly vertical in all directions and covered exactly the space provided for it in the circle. In order to effect this a wooden template was fixed on the staging from which these piles were driven, and the intended position of each joint was marked thereon by a nail. If it was found that the joints had a tendency to pass the proper mark on the template, the radius of the circle was slightly increased, and, vice versa, if the mark was not reached by the joint the length of the radius was slightly decreased.

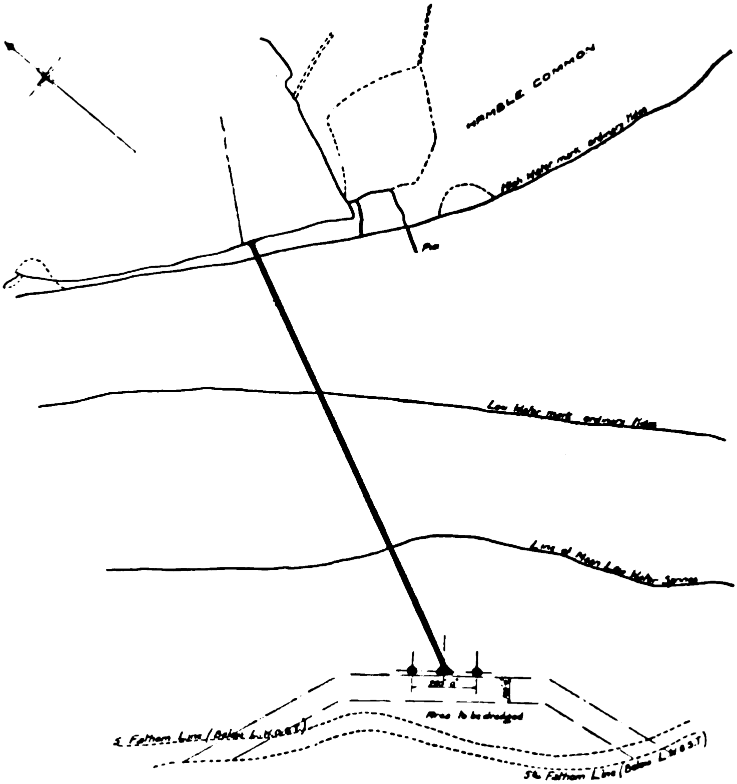

HAMBLE COMMON
High Water mark ordinary tides
Low Water mark ordinary tides
Line of Mean Low Water Springs
Area to be dredged
5 Fathom Line (Below L.W.O.S.T.)
5 Fathom Line (Below L.W.O.S.T.)

Fig. 6.

By thus carefully watching the position throughout the operations no difficulty occurred when the last pile closing the circle was driven and no jamming whatever took place.

The piers themselves were constructed of three rows of rolled steel joists, driven as piles and braced against each other by means of rolled steel channels. This construction can endure a considerable deflection at the top without serious consequences to the joists.

Other features in the general arrangement are two reinforced concrete dolphins for the stern hawsers and a light gangway connecting the concrete approach with the long pier arm. The hawser dolphins were constructed of nine reinforced concrete piles each, raking in different directions and kept together by a reinforced concrete capping. A view of the long arm with the two circular dolphins is shown in *Figs.* 4 and 5.

As a third example of dolphins with loose filling may be mentioned two dolphins built in 1924 for Messrs. Shell-Mex, Ltd., in order to provide a deep-water berth for unloading oil tank steamers at their station near Hamble, on the east side of Southampton Water. The problem in this case was a rather difficult one, as vessels of up to 20,000 tons had to be provided for and because the bottom consisted of mud down to a considerable depth. Messrs. Christiani & Nielsen decided to build the dolphins en-

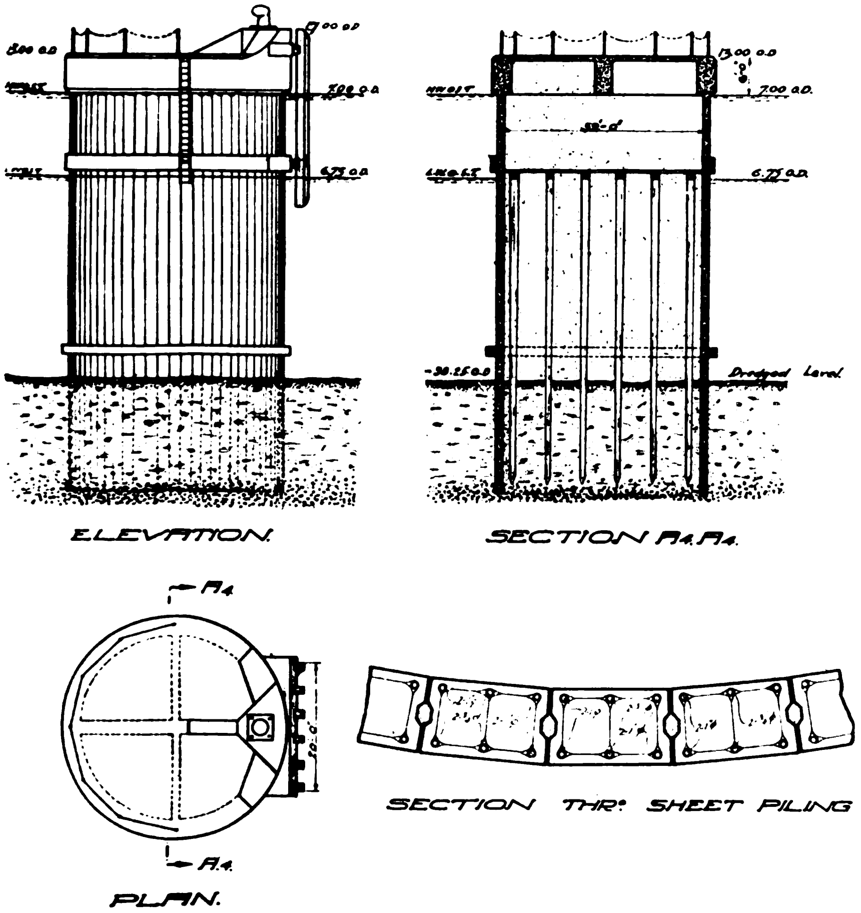


Fig. 7.

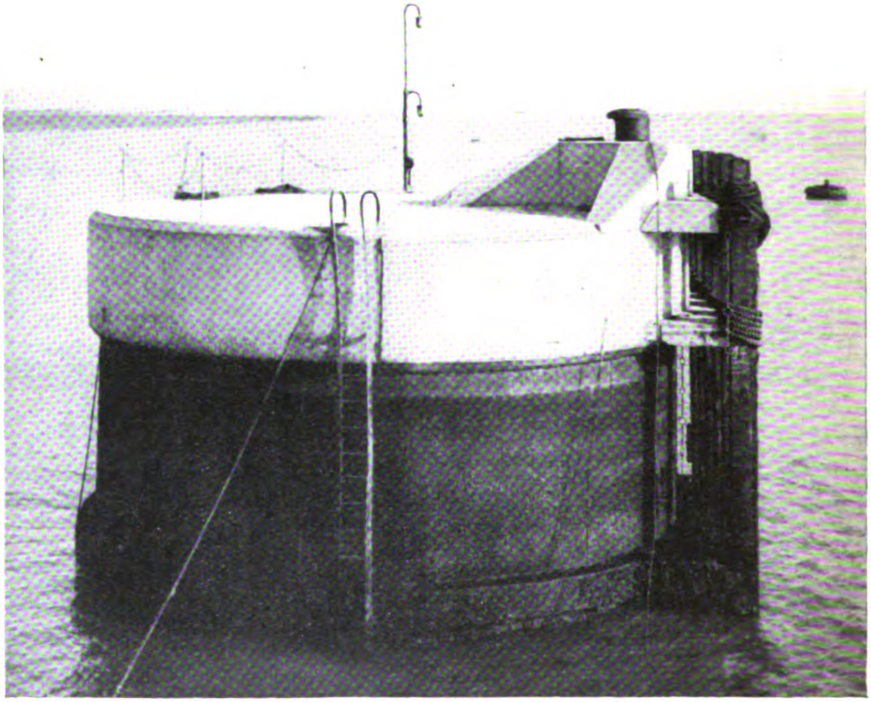


Fig. 8.

tirely of reinforced concrete in order to obtain a monolithic construction and thus ensure the greatest possible rigidity.

The general lay-out of the jetty can be seen from *Fig.* 6. It consists of a jetty 1634 ft. long, with a head of 60 ft. frontage, and two dolphins of 34 ft. diameter placed symmetrically 125 ft. on each side of the head. The jetty head is kept about 6 ft. back in relation to a line touching the two dolphins, in order that a vessel lying against the dolphins shall not bump against the jetty head.

The construction of the jetty head and the approach entails no unusual feature. The head consists of reinforced concrete piles, some of which are driven at a rake,

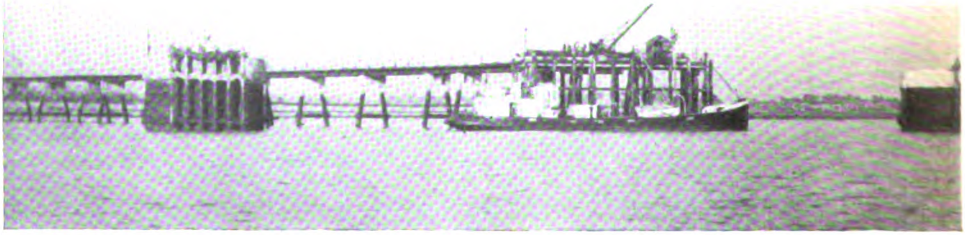


Fig. 9.

with a reinforced concrete bracing at low water level and a reinforced concrete decking. The jetty consists of reinforced concrete pile trestles generally 36 ft. apart, carrying a deck of steel joists and timber planking. Before the piles for the jetty head and the dolphins were driven the bottom was dredged to a level of 45 ft. 3 in. below high water, or 31 ft. 6 in. below low water, the deck level being 7 ft. 6 in. above high water level. It was necessary to drive the piles down to a level of 68 ft. below high water level in order to obtain a firm set.

The two dolphins consist of heavy reinforced concrete sheet piles of a slightly trapezoid section driven side by side in a circle and kept together by two reinforced concrete tie beams and a reinforced concrete capping. The filling is gravel. In order to ensure tightness of the dolphins the sheet piles were provided with longitudinal grooves at each side, two opposite grooves forming a hole which was afterwards filled with cement mortar.

In driving the sheet piles similar precautions as in the case of the Harwich dolphins had to be taken in order to ensure that the circle formed by the piles was exactly closed. It was anticipated that the closure pile might not fit exactly, and in this case it was the intention to drive a special pile of aluminous cement, cast to suit the opening. This, however, did not become necessary.

The reinforced concrete tie rings were cast of aluminous cement above high-water level, and afterwards lowered down round the piles to the required position. The joint between the sheet piles and the ring was afterwards grouted with cement mortar by divers.

A front view of the pier and the two dolphins is shown in *Fig.* 9, and of a single dolphin in *Fig.* 8. The dolphins have since their erection stood up to many a severe test, and answer their purpose exceedingly well. It is difficult to imagine, having regard to the prevailing conditions, how this could have been achieved with any of the usual constructions at a similar cost.

A Concrete Pavilion.

THE Southsea Castle Tea House, illustrated on p. 56, is chiefly composed of elevations of pre-cast blocks, columns, and ornamental pieces moulded by the contractor on the site.

The building was designed primarily to provide a store for the Beach Committee when chairs, bathing boxes, etc., require to be put under shelter during the winter. Workshops are provided at the rear for repairs, and it was arranged for the Beach Committee to have their offices on one side of the vestibule with three lock-up shops on the other. Lavatory accommodation was then added, and as the store is empty during the summer season it provides a shelter for visitors to Southsea Common, an area of 112 acres now being laid out as ornamental gardens with bandstand, tennis courts, bowling greens, etc.

As the building has a flat roof covered with asphalte, provision has been made for the serving of teas, and at the rear a fully-equipped kitchen with lifts from the ground floor to roof is provided for this purpose. Teas may be served in shelter during wet weather.

The building cost £8,500, and was started in May, 1925. It covers a superficial area of 1,150 yards; this is practically the area of the roof available as a terrace. Its frontage is 114 ft., and depth 91 ft. 6 in. The terrace is in two levels, so as to obtain light, by means of a kind of clerestory, to the shelter.

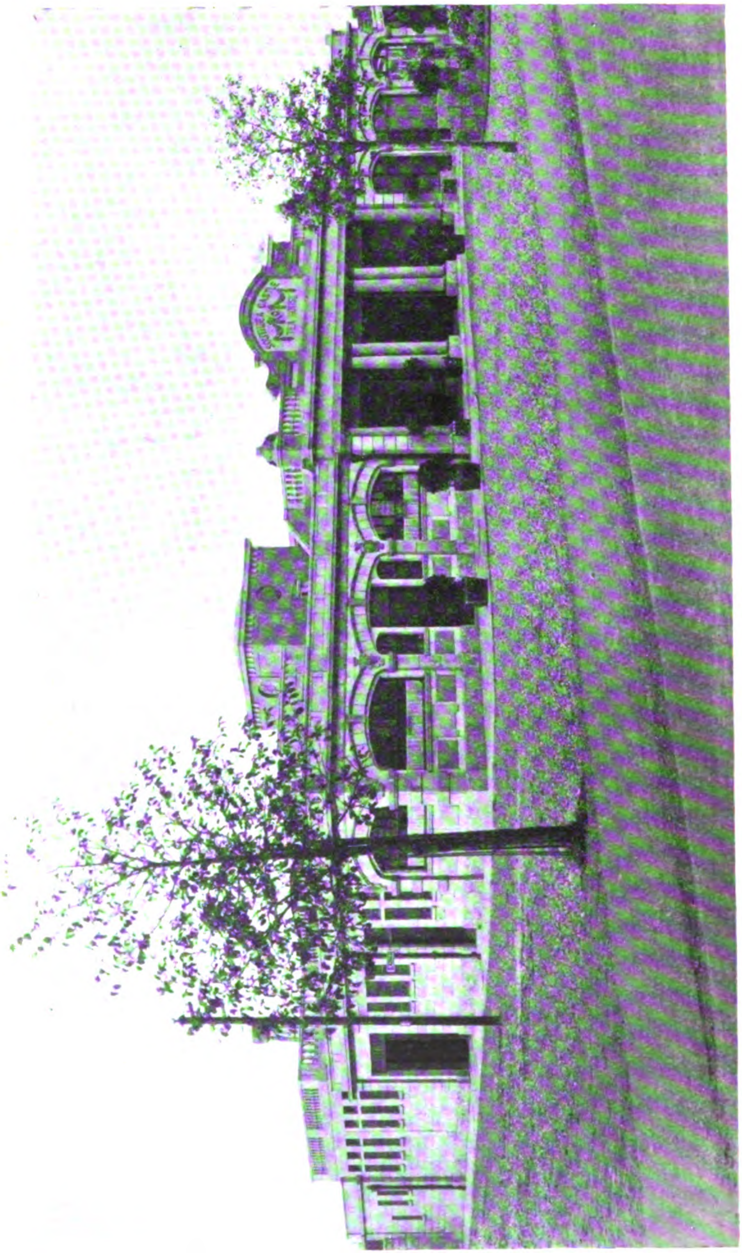
The foundations and floor are of reinforced concrete. Above this the walls are built in pre-cast blocks, but where the steelwork forms the skeleton of the building it has been encased with *in-situ* concrete. The roof is reinforced with expanded steel.

Two flights of concrete stairs give access to the roof from the main vestibule, and there is a service stairway at the rear for the staff.

The contractor provided on the site a long smooth concrete table for manufacturing the pre-cast blocks. The blocks for the front of the building and the columns of the vestibule, etc., were tinted with coloured cement, and the whole of the moulded work and the arch blocks were cast in the same material. The turrets were built in concrete reinforced with steel expanded mesh, as also was the saucer-dome roof.

The coloured cement for this work was supplied by Messrs. C. A. Peters & Co., Ltd., of Stores Road Works, Derby.

The building was designed by Mr. Arthur W. Ward, A.M.Inst.C.E., the City Engineer of Portsmouth, and erected by Mr. Jno. Croad, of Portsmouth.



A Concrete Pavilion. *(See p. 55.)*

Reinforced Concrete Regulations.

We have received the following from Mr. H. H. Jeffcott, Secretary of the Reinforced Concrete Joint Committee which was formed early in 1925 by the Institution of Civil Engineers, the Royal Institute of British Architects, the Surveyors' Institution, and the Institution of Structural Engineers, to consider the proposals in the L.C.C. (General Powers) Bill, 1926, in which it was provided that the power of the Council to issue regulations for reinforced concrete construction should be extended with respect to the conversion of any building or part of a building constructed wholly or partly of reinforced concrete :

The Reinforced Concrete Joint Committee, having obtained the authority of the four Institutions, arranged for the lodgment of their petitions in the House of Lords against the L.C.C. (General Powers) Bill 1926, and was heard by counsel and witnesses before a Standing Committee of that House. In the opinion of the Committee the Bill was of much too wide a scope, and would give the L.C.C. almost autocratic powers without appeal in all cases where a building was not only converted in such a manner as to require partial reconstruction, but even by mere change of user without any constructional work at all.

As a result of the hearing, and following on consultations between members of the Committee and the technical officers of the London County Council, revisions to the original Bill were agreed to. The London County Council indicated its willingness to modify the Bill so as to remove the whole of the Committee's objections. Briefly, the amendments to the original Bill brought about the following changes :—

1. To limit the application of the Act to a case " which in the opinion of the District Surveyor affects or is likely to affect the stability of buildings or the safety of persons occupying or resorting to such buildings."

2. To secure the right of appeal to the Tribunal of Appeal in case of dissatisfaction with the refusal of the Council to modify or waive any requirements of any regulations made under this Section.

3. To extend to the Institutions represented on the Committee the right enjoyed by them in the 1909 Act, namely, to receive notification of an intention of the Council to apply to the Ministry of Health for allowance of new or amended Regulations.

4. To exclude from these provisions its application in the case of any erection, alteration, etc., of buildings in accordance with the provisions of the London Building Acts, 1894–1908, and to prevent any right or privilege vested in or enjoyed by any person under these above-mentioned Acts being prejudiced or taken away.

The following shows the additions and deletions made to the Bill during its passage through Parliament. Additions are in italics, deletions are square bracketed:

5. (1) The provisions of Section 23 (Power to make regulations as to use of reinforced concrete) of the London County Council (General Powers) Act 1909 (in this Part of this Act referred to as " the Act of 1909 ") shall extend to enable the Council subject to the provisions of that section to make and enforce regulations with respect to the conversion of any building or part of a building constructed wholly or partly of reinforced concrete [so that such building or part of a building when converted would not be in conformity with the regulations applying to such construction].

(2) *Any regulations made under section 23 of the Act of 1909 as amended by this section which relate to the stability of a building or part of a building shall be so described in such regulations.*

(3) In order to facilitate the erection of any particular building or part of a building intended to be constructed wholly or partly of reinforced concrete or the conversion of any particular building or part of a building so constructed, the Council may in relation to that building or part of a building modify or waive upon and subject to such terms and conditions as they think fit any of the requirements of the regulations made under section 23 of the Act of 1909 as amended by this section ;

(4) *Any person dissatisfied with the refusal of the Council to modify or waive any of the requirements of any regulation made under section 23 of the Act of 1909 as amended by this section (other than a regulation described as specified in sub-section (2) of this section) or with any term or condition which the Council may attach*

to any such modification or waiver, may appeal to the Tribunal of Appeal as constituted under section 25 (*Tribunal of Appeal, etc.*) *of the Act of* 1909 *and the provisions of that section shall apply with respect to any appeal under this section.*

(5) Any person failing to comply with any term or condition attached to any such modification or waiver as aforesaid shall be liable on summary conviction to a penalty not exceeding twenty pounds and to a further penalty not exceeding twenty pounds for each day on which the offence continues after conviction thereof.

(6) For the purposes of this section a building or part of a building shall be deemed to be converted not only when it is structurally altered but also if and whenever any change *which in the opinion of the district surveyor affects or is likely to affect the safety of persons occupying or resorting to or the stability of such building or part of a building* is made in the purposes for which the building or part of a building is used.

(7) *The Council shall give to the Institution of Civil Engineers the Institution of Structural Engineers the Royal Institute of British Architects and the Surveyors' Institution notice of their intention to apply to the Ministry of Health for allowance of any regulations made under section* 23 *of the Act of* 1909 *as amended by this section.*

(8) *The provisions of section* 23 *of the Act of* 1909 *as amended by this section and any regulations in force thereunder shall not apply in the case of the erection or alteration of or the making of an addition to or the doing of other work to in or upon any building in accordance with the provisions of the London Building Acts* 1894 *to* 1908 *and nothing in section* 23 *of the Act of* 1909 *as amended by this section or any regulations in force thereunder shall take away or prejudice any powers rights privileges or exemptions vested in or enjoyed by any person under the London Building Acts* 1894 *to* 1908 *or any of them.*

(9) *Nothing in any regulations made under section* 23 *of the Act of* 1909 *as amended by this section shall apply to any building which conforms with—*

(a) *the provisions of the London Building Act* 1894 ; *or*

(b) *the provisions of section* 22 (*Provisions with respect to buildings of iron and steel skeleton construction*) *of the Act of* 1909 *or those provisions as varied by any modification or waiver made or granted in pursuance of that section or of section* 5 (*Provisions with respect to buildings of iron and steel skeleton construction*) *of the London County Council* (*General Powers*) *Act* 1923.

(10) The provisions of this section and any regulations made thereunder and for the time being in force shall be deemed to form part of Part VI of the London Building Act 1894.

(11) *The powers conferred by subsection* (3) *of this section shall not be exerciseable before the first day of January one thousand nine hundred and twenty seven or the date on which any regulations made under section* 23 *of the Act of* 1909 *as amended by this section first come into operation whichever of those dates shall be the earlier.*

6. *Notwithstanding anything contained in section* 24 (*This Part of Act and Regulations to form part of Part VI of London Building Act* 1894) *of the Act of* 1909 *or in subsection* (10) *of the section of this Act of which the marginal note is " Regulations as to reinforced concrete buildings " any regulations referred to in those sections or either of them shall be subject to the provisions of section* 32 *of the Interpretation Act* 1889.

7. (1) So much of subsection (5) of section 23 of the Act of 1909 as requires the publication in the London Gazette of regulations made under that section shall cease to have effect.

(2) When any regulations made under [the said] section 23 *of the Act of* 1909 as [extended] *amended* by this part of this Act have been allowed and are open to public inspection and copies thereof can be obtained in accordance with the provisions of that section as so [extended] *amended* [notice thereof shall be published by the Council in the London Gazette] *the Council shall publish in the London Gazette notice of the making and allowance of such regulations with an intimation as to the place at which the regulations can be inspected and copies thereof can be obtained.*

8. Section 26 (Increase of fees to district surveyors) of the London County Council (General Powers) Act 1921 shall be read and have effect as if the thirty-first day of December one thousand nine hundred and twenty-seven were substituted in paragraph (A) of subsection (4) and in sub-section (7) thereof for the thirty-first day of December one thousand nine hundred and twenty-six.

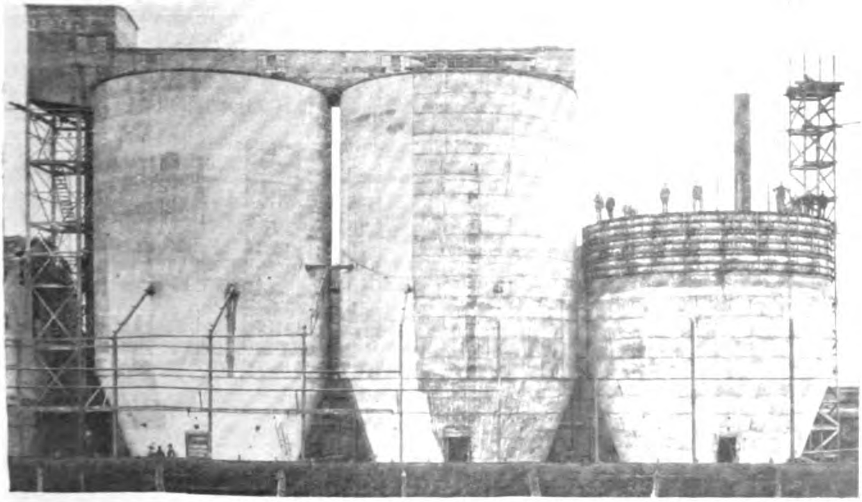
REINFORCED CONCRETE IN 1926.

In the following pages we give a record of the reinforced concrete work in hand or completed during 1926 by most of the leading firms in the industry. These notes and illustrations give a good idea of the enormous amount of building and constructional work now being done in reinforced concrete, and also of the variety of purposes for which it is found to be the most suitable and economical material.

Anglo-Danish Concrete Construction Co., Ltd.

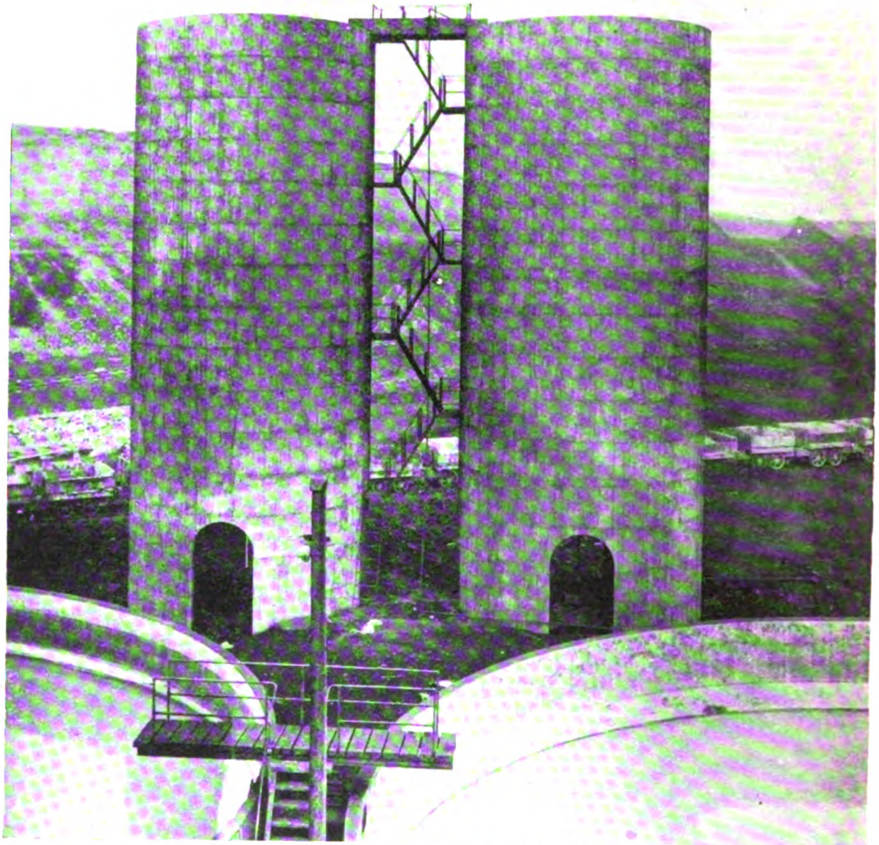
Most of the work of this firm has been in connection with cement factories, and comprises extensions to cement mill, new slurry basins for compressed air, two chimneys, extension to coal mill and foundations, for the Tunnel Portland Cement Co.; loading jetty, cement silos, etc., for Messrs. G. & T. Earle (1925), Ltd.; cement silos, loading platforms and foundations for the Aberthaw and Bristol Channel Portland Cement Co.; foundations, basins and new wash mill building for the British Standard Cement Co.; all the reinforced concrete work in connection with the extension to Messrs. Smeed, Dean & Co.'s cement factory, comprising coal mill, coal bunkers, cement mill, cement silos, pumping platform, underground tunnel, etc. The firm is also carrying out a new crusher-pit foundation and retaining walls for the Ship Canal Portland Cement Manufacturers, Ltd. at their quarries in North Wales, and kiln foundations and chimney for their works at Ellesmere Port; sewage disposal works for the Sturminster Newton Rural District Council, Dorset, etc. Work abroad comprises several grain elevators, wharves, culverts, reinforced concrete work for cement factories, etc.

An interesting chimney reconstruction carried out by this firm is illustrated and described elsewhere in this number.



[Anglo-Danish Concrete Construction Co., Ltd., R.C. Designers and Contractors.

Silos in course of Erection.



[*Anglo-Danish Concrete Construction Co., Ltd., R.C. Designers and Contractors.*

Slurry Mixers and Silos.

Sir William Arrol & Co., Ltd.

During the past year continued advance has attended the various works of construction being carried out by the Reinforced Concrete Department of this firm, and several new works have been undertaken.

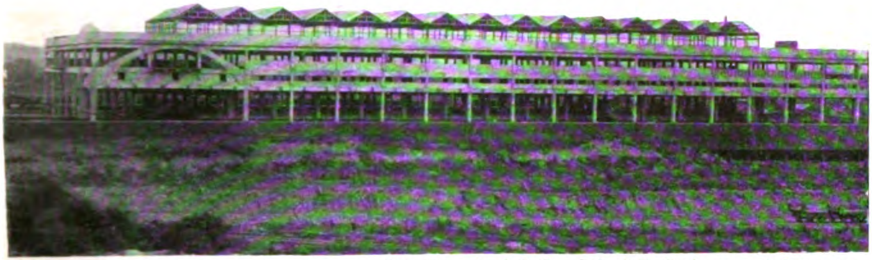
Despite the incidence of the coal strike, rapid and continuous progress has been made with the Royal Edward Dock Extension at Avonmouth, where 4,000 lineal feet of wharves, two granaries and two transit sheds are in course of construction.

Other contracts in progress include Carlton Bridge, for the West Riding of Yorkshire; Hawes Pier Extension at South Queensferry, for the London & North Eastern Railway; Lanarkshire Hydro-Electric Scheme, which includes power-houses, bridges, weirs, tunnels, and surge tanks; four bridges on the Bexley Heath By-pass Road; and extensive additions to cement works at Haverton Hill.

During the year the firm completed jetties for the Tynemouth Corporation, and a warehouse for Wylie & Lochhead, Ltd., of Glasgow.

Frank Bevis, Ltd.

Among works completed in 1926 by this firm is Boscombe Pier, for the Bournemouth Town Council. Briefly, this was a piled structure with 15-in. octagonal piles



[Sir Wm. Arrol & Co., Ltd., R.C. Designers and Contractors.

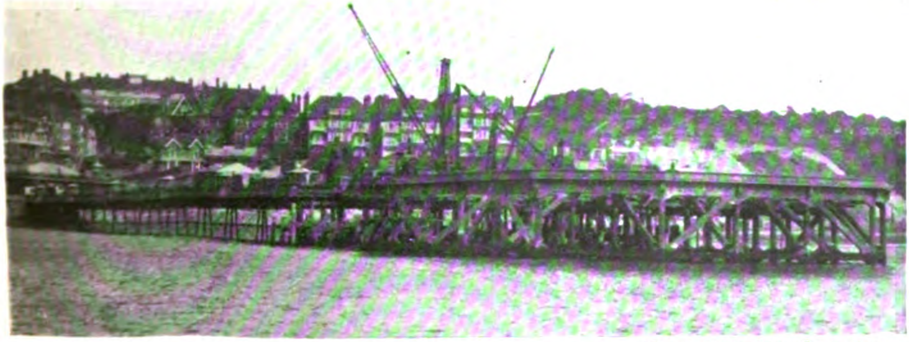
Transit Shed at Avonmouth.

driver by aid of water jets about 8 ft.–10 ft. below ground level, with a braced superstructure, and tee-deck beams upon which was fixed Jarrah decking. This work was fully illustrated and described in our number for December 1926.

The widening of Camber Docks, Portsmouth, for the Portsmouth Town Council was also completed. This contract consisted of the removal of the old dock wall of masonry and mass concrete by means of coffer dams, and the substitution of a modern type of construction, a sheet piled face fixed into a heavy coping beam, with a beam and slab construction about 8 ft. from surface level tying the face back to straddle raking piles about 40 ft. long driven at a rake of 1 in 3. Owing to presence of running sand and close proximity of buildings, this presented a number of engineering difficulties which were successfully surmounted. This work was also described in our number for December last.

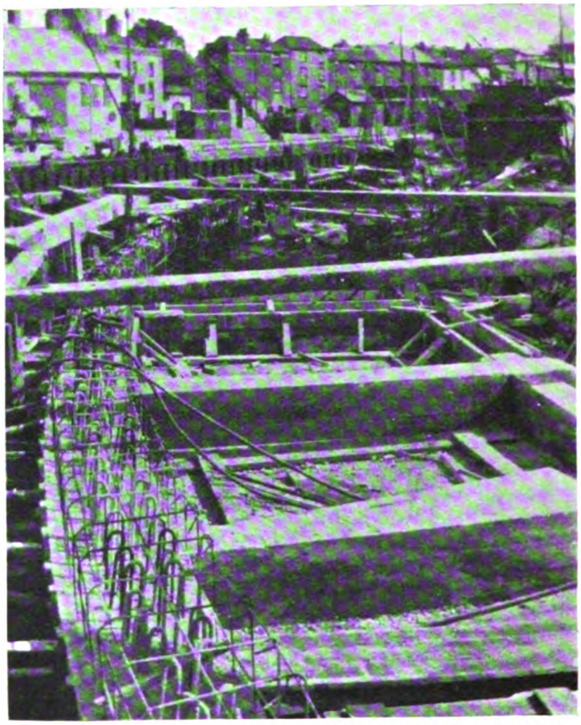
Henry Boot & Sons, Ltd.

This company now has no less than 3,650 concrete houses in hand in various parts of the country, which, when completed, will make the total number of concrete houses by this firm 12,078. Schemes now completed include: West Bromwich (604 houses), Lichfield (254), Bilston (438), Banbury (128), Brackley (92), Middleton Cheney (20), Towcester (58), Brailes (42), Atcham (64), Bromsgrove (132), Uttoxeter (70), Alcester (54), Montgomery (41), Rotherham (60), Bullcroft Colliery (52), Markham Colliery (52), Bulwarks (Office of Works) (209), Bakewell (50), Chapel-en-le-Frith (134), Feckenham (30), Portslade (62), Steyning (104), Hoo (96), Slough (212), Farnborough (16), Bradford (786), Glapwell Colliery (148),



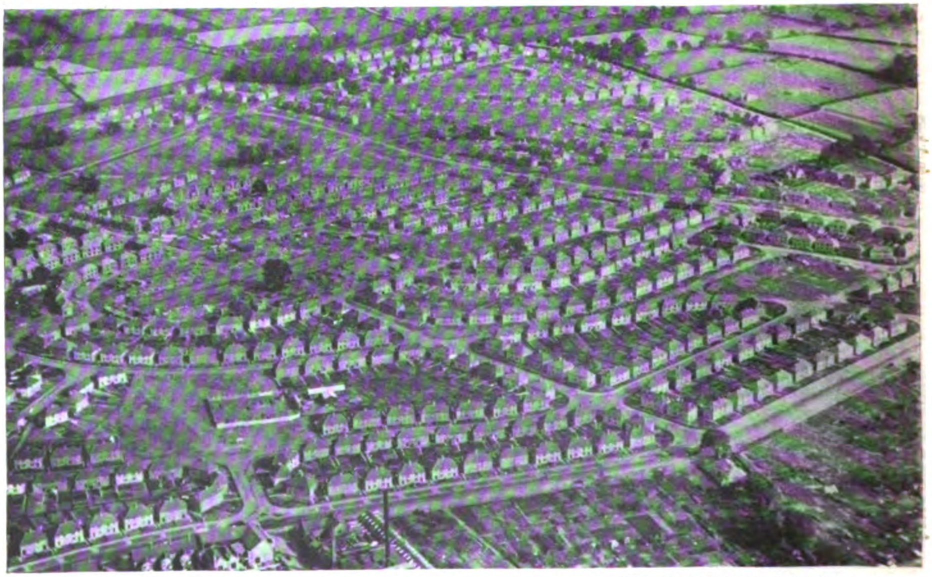
[Frank Bevis, Ltd., Contractors.

Reconstruction of Boscombe Pierhead.



[Frank Bevis, Ltd., Contractors.

Widening of Camber Dock, Portsmouth.



[Hy. Boot & Sons, Ltd., Contractors.

Concrete Houses at Leicester.

[Reinforcement by British Reinforced Concrete Engineering Co., Ltd.

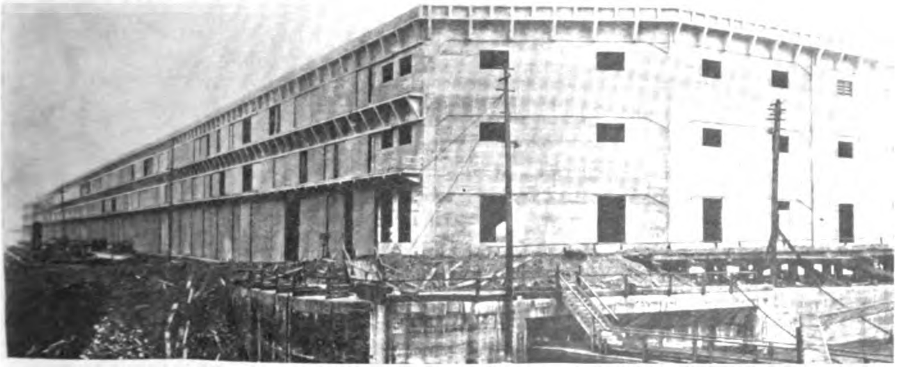
Precipitation Tanks at Stockport Sewage Disposal Works.

Havecroft Colliery (189), Langwith Colliery (272), Leicester (698), Maltby Colliery (40), Sheffield (1,000), Birmingham (1,344), Stafford (Works) (69), Tilbury (208), sundry smaller schemes (600).

Schemes now on hand include: Bradford (482 houses), Leicester (802), Liverpool (1,000), Dundee (500), London (698), Birmingham (168).

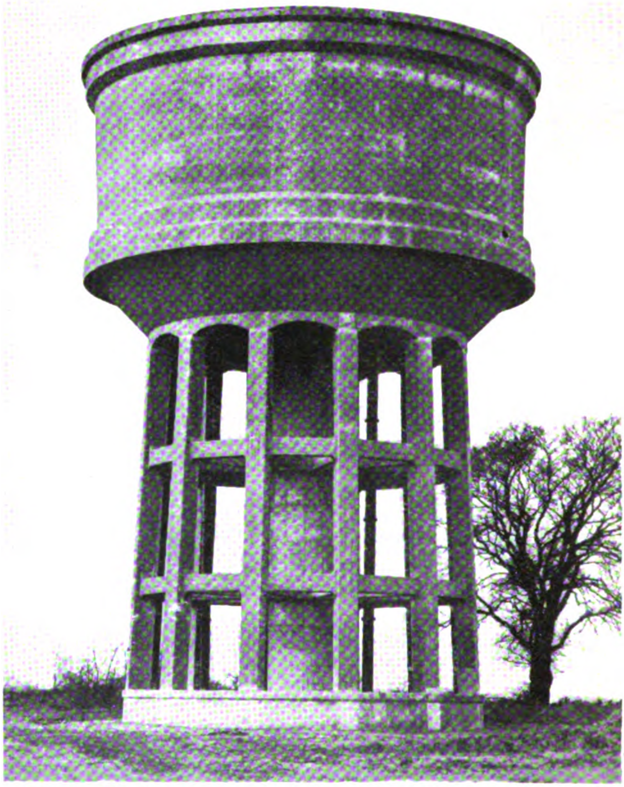
British Reinforced Concrete Engineering Co., Ltd.

Gladstone Dock, Liverpool.—In this scheme (perhaps the largest industrial reinforced concrete work in the country) four 3-story sheds are included, each of which is constructed entirely of reinforced concrete and founded on reinforced concrete piles. The sheds will be used for storage purposes during transit of goods to and from the Port. Shed A is 1,500 ft. long by 150 ft. wide. Sheds B, C, and D are each approximately 1,200 ft. long by 100 ft. wide. All the sheds are carried on reinforced concrete piles averaging about 50 ft. in length and arranged in groups under the various columns and walls. Each group of piles supports a pile cap which carries the column above. In the case of the internal columns the design load is approximately 1,000 tons. The first and second floors are designed respectively for super-imposed loads of 30 and 25 cwt. per sq. yd.; the roofs are designed for superimposed loads of 20 cwt. per sq. yd., and in addition are arranged to carry travelling cranes.



[Reinforcement by British Reinforced Concrete Engineering Co., Ltd.

Gladstone Dock, Liverpool.



[*Reinforcement by British Reinforced Concrete Engineering Co., Ltd.*

300,000-gallon Water Tower at Cantley.

Brace Bridge, Lincoln.—This work is typical of much of the bridge widening and reconstruction work which is being carried out throughout the country. An existing bridge has been widened by 25 ft. on one side and 10 ft. on the other, thus providing a carriageway of 40 ft. and side walks of 8 ft. on each side. The widening consists of three arch slabs carried by reinforced concrete abutments and river piers, the whole of the widening being supported on reinforced concrete piles. The finished structure, as shown by the photograph, presents a very pleasing appearance.

Water Tower, Cantley.—The tower shown in this illustration has recently been completed for the Corporation of Doncaster. The tank has a capacity of 300,000 gallons, and is supported by twelve columns braced radially and circumferentially at intervals of about 16 ft. in their height, the whole being carried on a continuous circular foundation. The tank has a dome floor and roof, and an inside circular division wall which permits of the tank being cleaned without interfering with the supply of water. Access to the interior is provided by a helical staircase inside a central circular wall. The columns have been designed with a slight batter toward the centre, and this, together with a curtain wall at ground level, adds to appearance without appreciably increasing cost.

Stockport Sewage Works.—This scheme, a portion of which is illustrated, has been carried out almost entirely in reinforced concrete construction. The works generally comprise aeration tanks, pyramidal settling tanks, sumps and pump wells, screening chambers, and long lengths of reinforced concrete channelling supported above the ground on sleeper walls. The complete scheme has been carried out under five separate contracts, the last of which is now nearing completion. In the case of all the low-level work, and in some of the deeper tanks, ground water and loose sand have added considerably to the difficulties of construction.

2,000-*Ton Coal Bunker, Parkgate.*—This work, recently completed for the South Yorkshire Chemical Co., at Parkgate, to the order of the Semet-Solvay & Piette Coke Oven Co., Ltd., is 40 ft. wide by 60 ft. long, and has a total height above ground of approximately 130 ft. The capacity of the bunker is 2,000 tons. The weight of the coal and of the superstructure is carried by a system of main and secondary beams at the hopper-mouth level, these beams being supported by eight isolated columns which in turn transmit the loads to two continuous foundation rafts, one under each set of four columns.

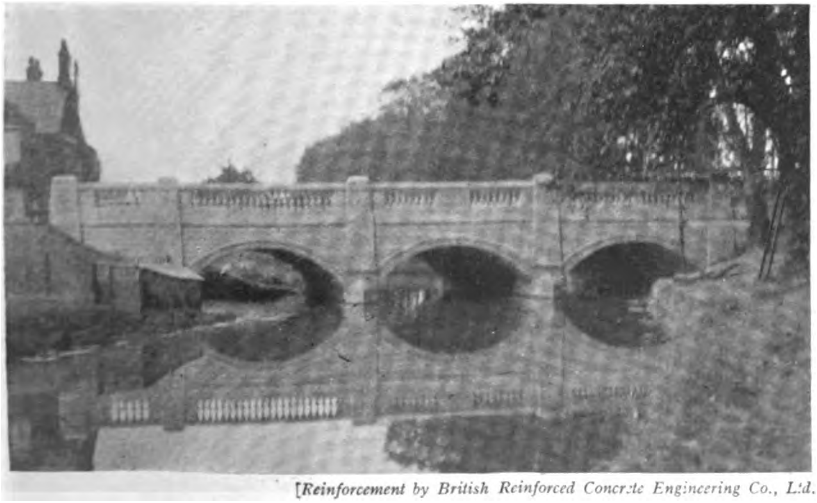
On the same site numerous other reinforced concrete structures have been erected, including a large underground coal hopper 30 ft. deep; five tar and liquor tanks, each about 20 ft. diameter and elevated on columns with the usual system of bracing; coke hoppers; conveyor subways; and other smaller works.

Many other bridges have been erected in various parts of the country, the chief being Coombe Dingle Bridge, Bristol; Finedon Bridge, for the Northants C.C.; Brimington Bridge, Chesterfield; Barnoldswick Bridge; Blythe Bridge, Uttoxeter; Grasmere Bridge; and several bridges for the Irish Free State.

Factories, warehouses, laundries, mills, and office buildings include the Public Health Institute, Dundee; The Younger Hall, St. Andrews; Ballymena Town Hall; Associated Newspapers and "Daily Mirror" offices; premises at Swansea; factory at Billingshurst; silk mills at Leek, Staffs; laundries at Brentford, Stepney, and Chesterfield. Picture theatres include Charing Cross Cinema & Dance Hall; New Barnet Cinema; Stamford Cinema; Peterborough Cinema; Scunthorpe Cinema; Hounslow Empire; Picture House, Aldershot; and Picture House, Bristol.

Swimming baths include Normanton Baths, Leeds Baths and Thurnscoe Miners' Welfare Bath and Wash-house.

Hospitals and infirmaries where B.R.C. reinforcements have been used are as follows:—Lewisham, East Ham, Sunderland, Preston, Milford, Surrey, and Mearnskirk. Universities, colleges and schools are represented by Raffles College, Singapore; Cardiff University; Bede College, Durham; Bedford Girls' High School; Hertford Girls' School;



[Reinforcement by British Reinforced Concrete Engineering Co., Ltd.

Brace Bridge, Lincoln.

Hawarden County School; Barnet School; Holywell County School; and schools at Leicester, Wolverhampton, Kilmarnock, Saltcoats, Ammanford, Vauxhall, and Poplar.

Banks include branches of the National Provincial Bank at Piccadilly, Southport, Cardiff, Exmouth, Shrewsbury, Halifax, Woodbridge, Driffield, and Hendon. The complete sub-structure and upper floors to the head office of the Midland Bank at Poultry, E.C., have been erected entirely to B.R.C. design and specification as well as branches at Louth, Launceston, Newport and Prestwich for the same bank.

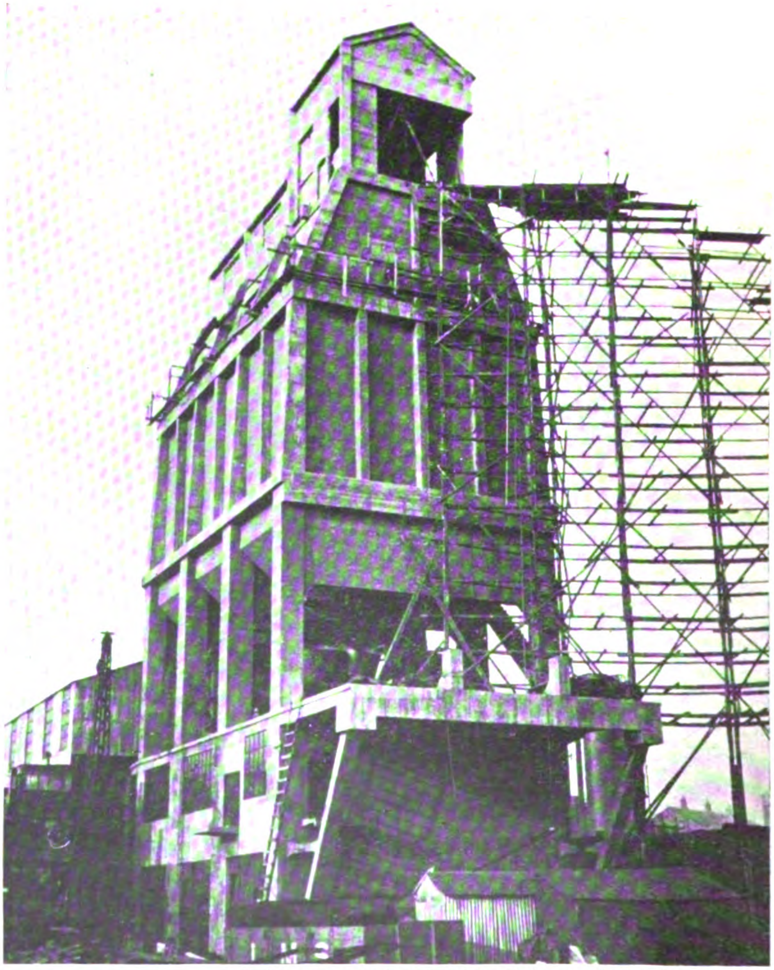
Other works include goods depot at Temple Meads, Bristol; tram depot at Nottingham; omnibus park at Doncaster; Derby County Rugby Football Stand; and Boythorpe culvert, Chesterfield.

The Company has also supplied the reinforcement for over 100 miles of road during the past twelve months.

Christiani & Nielsen.

During the past year works completed by the firm include:—

For the Metropolitan Water Board.—The complete construction of a series of



[Reinforcement by British Reinforced Concrete Engineering Co., Ltd.

2,000-ton Coal Bunker near Rotherham.

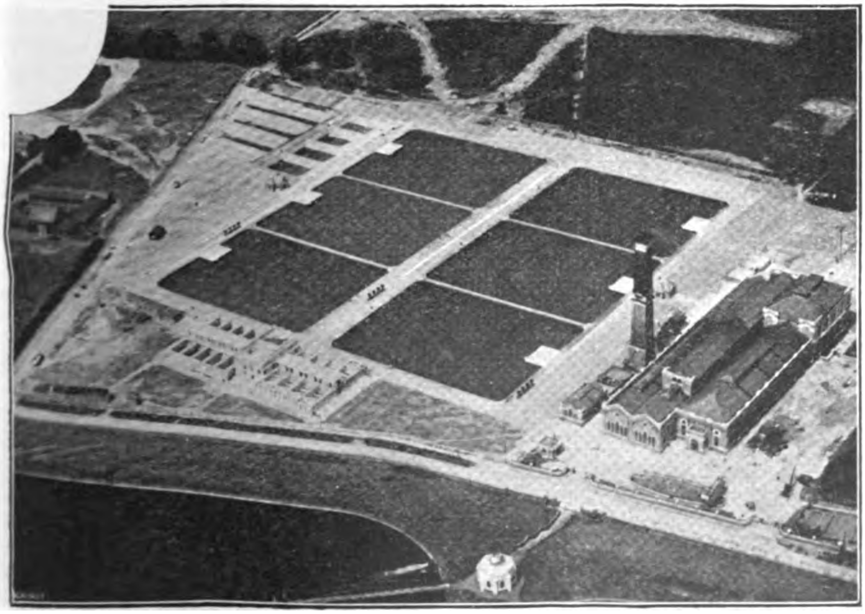
large open filter beds covering 5 acres, together with auxiliary works, heavy pipe-laying, and roads, at the Walton Reservoirs, including the building in reinforced concrete above ground of No. 18 primary filter beds or tanks, and the erection of the housing accommodation for compressors and pumps connected with the installation.

Messrs. Doulton's New Works.—In connection with the erection of the new factory which this firm is building at Erith, Messrs. Christiani & Nielsen have designed and constructed, under the architect, the whole of the piling, raft, and machinery foundations embodied in an extensive lay-out, on a completely new site, for the buildings required for the various groups of structures.

For the Shell Mex Oil Co.—At Shell Haven, in connection with the installation of a large coal-handling plant, the firm has in hand the construction of a reinforced concrete barge unloading jetty, together with the raft and pile foundations for boiler house, cooling tower, coal silo, etc., which are founded on very bad ground. The coal silo, which is reinforced concrete, has a capacity of 2,500 tons, and the details of reinforcement design for this and the other works have been prepared by the firm in collaboration with Messrs. International Combustion, Ltd., who are the makers and erectors of the machinery and handling plant erected on the several works.

Factory in Ireland.—One of the first factories to be built under the Free State Government régime in Ireland has just been completed by the firm for a farmers' association in County Waterford. The factory, which is connected with the meat industry, cold storage, and dairy produce, is built entirely of reinforced concrete, an exceptional feature of the factory being the amalgamation of thin concrete walls and cork slabs for completely insulating a number of the component buildings and sections of the factory. The firm in this case also designed for the Association's architect the whole of the reinforced concrete work.

For the Gas Light & Coke Company.—The construction at their Nine Elms station of a gas purifier tank, consisting of a series of eight compartments, built on columns and elevated above the ground. As these compartments had to be gas-tight, exceptional care and methods were adopted in the selection of aggre-



[Christiani & Nielsen, R.C. Designers and Contractors.

Filter Beds at Walton.

gates and the mixing of the concrete to ensure an impervious mixture. The result obtained after test was so satisfactory that the firm has been entrusted with the construction of a similar tank at the Kensal Green station of the same Company, which work is now in progress.

For the Minerals Concentration Co., Ltd.—The construction of two landing piers, 235 ft. and 70 ft. in length, at Dinmor Park Quarry on the Anglesey coast near Beaumaris. The piers are founded on solid rock, carried on reinforced concrete columns of substantial section to resist the heavy seas which the site is subject to, this factor being one which also had to be taken into account when designing to enable the actual construction to be possible of execution. Reinforced concrete open construction was adopted to allow the area of water between the piers to have free flow, and prevent surging of vessels moored to the piers. The firm was entrusted with the complete designing of the works and all the reinforcement details. At the same quarry an existing steel pier which was in a bad state of corrosion has been completely encased in concrete and now presents the appearance of an entirely new structure.

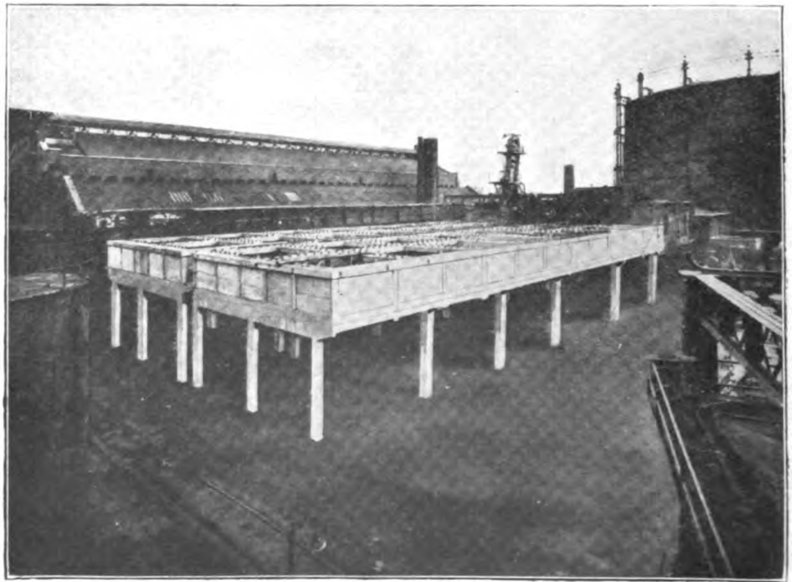
For the Duke of Grafton.—A reinforced concrete bridge on the Little Ouse near Thetford. The bridge, which was built to replace an existing oak structure of novel design, maintains certain traditions connected with the ducal succession and is designed to harmonise with the amenities of the estate and its close proximity to a country seat. All exposed surfaces are coated with white cement.

For the Surrey County Council.—The construction of two highway bridges on the new Kingston By-Pass road near Raynes Park, both spanning the Southern Railway. All sections of the work are in reinforced concrete, the foundations alone involving the making and driving of 900 concrete piles. The use of props to support temporary works and centering being, in the case of the main beams spanning the railway, totally prohibited, much skill had to be adopted to support the falsework during the depositing and setting of the concrete. The weight in certain beams is 30 tons, and a series of specially built steel girders from which the centering is hung from below is being adopted. This work is now in hand.

Edmond Coignet, Ltd.

Among the works designed by this firm and in course of execution during 1926 are the following:

G.P.O. at Singapore, for the Crown



[*Christiani & Nielsen, R.C. Designers and Contractors.*

Filter Tanks at Walton.

[R.C. Design by Edmond Coignet, Ltd.

Sunk Roadway for the Weymouth Corporation.

Agents to the Colonies (described in our issue for January 1926); Municipal Buildings at Singapore, for the Municipality of Singapore (illustrated in our issue for October 1926); Water tower at Bath, for the Bath Corporation; Cement silos at Bevans Works, for the Associated Portland Cement Manufacturers, Ltd. (described elsewhere in this number); Mill for Messrs. Patons & Baldwins, at Halifax; Culvert at Accrington, for Messrs. Howard & Bullough; Retaining wall for the Barnet Gas Co.; Bunkers for the Glasgow Iron & Steel Co., at Wishaw; Wharf at Silvertown for Messrs. Pinchin & Johnson; Mill for Messrs. Brough, Nicholson & Hall, at Leek; New offices and showrooms for the Newcastle Motor Co., Staffs; Wall, for the Tottenham Gas Co.; Sunk subway, for the Weymouth Corporation; Sewage tank, for the Sedgefield U.D.C.; Water tank at Merthyr Tydfil, for the U.D.C.; Foundations for Messrs. Doultons, Ltd., at Erith; Buildings for the Bell Telephone Manufacturing Co., at Antwerp; Raft for retorts, for the Worthing Gas Co.; Reconstruction of Old Barnwell Theatre, Cambridge; Retaining wall, Glentworth Bay, Weston-super-Mare; Bridge, for the Waterford Gas Co.; Clay silo at Wishaw, for the Glasgow Iron & Steel Co.

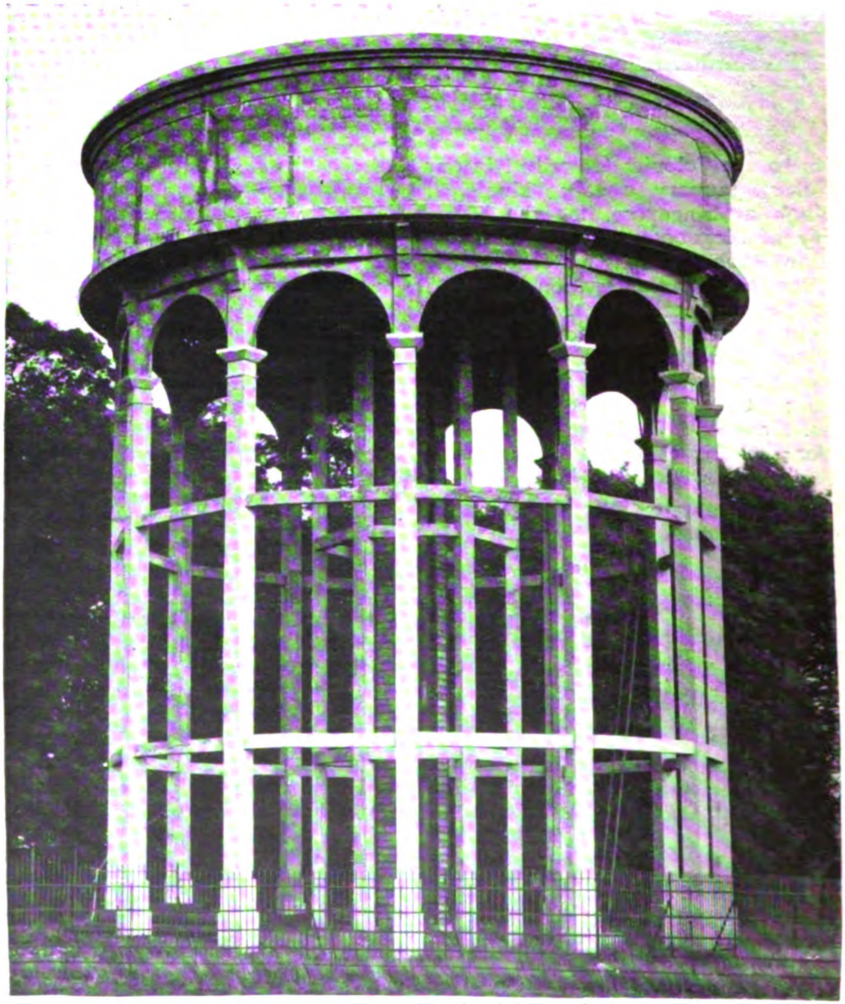
Water Tower.—The water tower for the Bath Corporation is situated on the top of a hill, and is consequently very much exposed to the wind. As the total height of the tower measures about 65 ft., the work had to be calculated strong enough to resist heavy wind pressures in addition to the weight of water. The tank is supported by six central pillars and twelve outer pillars 15 in. by 15 in., suitably braced and having a height of 45 ft. The work and the general design were carried out under the supervision of Mr. Jules Dent Young, A.M.I.C.E., Waterworks Engineer of the Bath Corporation, and the working drawings for the reinforced concrete were prepared by Messrs. Edmond Coignet, Ltd. The general dimensions of the tank are 11 ft. in height measured from the inside of the bottom to the top of the cornice, and the inside diameter 45 ft. 3 in. The capacity is 100,000 gallons with a height of water of 10 ft. It is covered by a reinforced concrete dome surmounted by a lantern for ventilation purposes. The inlet and outlet and overflow pipes have been grouped in the centre of the tank and adequately protected from frost. The height of the tower from ground level is 45 ft., and the foundations have been carried down 4 ft. 6 in. and are resting on the solid rock upon isolated footings.

The retaining wall alongside the river, for the Tottenham Gas Co., was carried out by the Monnoyer British Construction Co. The length of this wall is about 288 ft., and the height 8 ft. Piles were driven into the ground and pre-cast panels placed in position at the back of the piles.

The same contractors also carried out the sunk roadway, 300 ft. long by 40 ft. wide, for the Weymouth Corporation. This roadway, which is supported on reinforced concrete piles, is below water level, and was therefore constructed somewhat after the manner of a tank. The work was carried out under the supervision of Mr. Jamieson, the Borough Engineer.

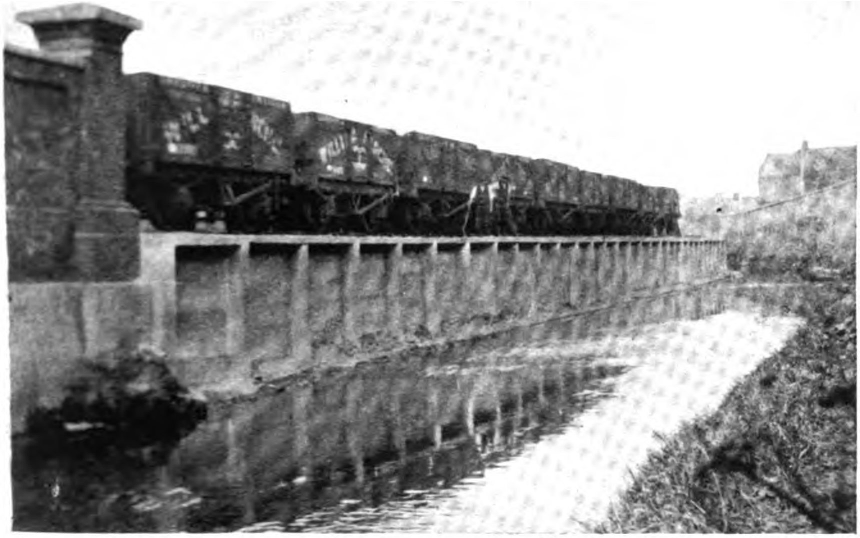
The crane track recently constructed on the Coignet system by Messrs. H. M. Murray & Co., of Glasgow, for the Glasgow Iron & Steel Co., at Wishaw, is 200 ft. long and about 50 ft. high, and is notable for the particularly fine finish the contractors have given to the surface.

When it is completed, the Marine Lake at Glentworth Bay, Weston-super-Mare (construction of which has just begun) will be the largest marine lake in this country, as it encloses about 8 acres of water. The sea wall which cuts off Glentworth Bay is composed of reinforced concrete caissons each 20 ft. long by 12 ft. wide by 10 ft. high, filled with sand after being floated in position. These caissons will rest on a prepared mass concrete



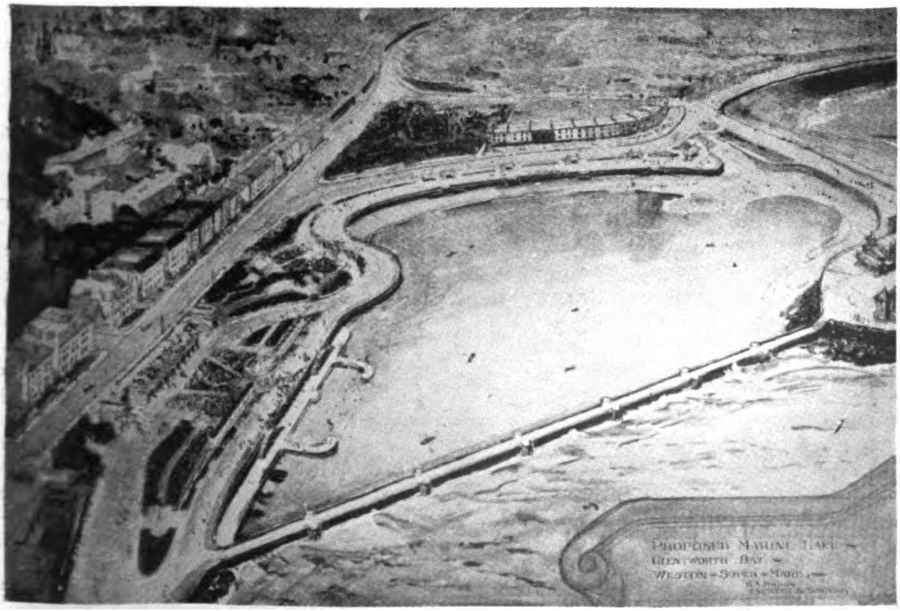
[Reinforced Concrete Design by *Edmond Coignet, Ltd.*

100,000-gallon Water Tower for Bath Corporation.



[R.C. Design by Edmond Coignet, Ltd.

Retaining Wall for Tottenham Gas Co.



[R.C. Design by Edmond Coignet, Ltd.

Marine Lake, Glentworth Bay, Weston-super-Mare.

[R.C. Design by Edmond Coignet, Ltd.

Interior of Building for Bell Telephone Manufacturing Co.

foundation. This scheme was approved by the Ministry of Health, and Messrs. Coignet have been appointed consulting engineers for the work in collaboration with Mr. H. A. Brown, Borough Engineer of Weston-super-Mare. The contractors are Messrs. Nott Brodie & Co., Ltd.

The working drawings for the reinforced concrete work for the buildings for the Bell Telephone Company, at Antwerp, were prepared in Messrs. Coignet's London office under the supervision of Mr. F. S. Giller, Plant Engineer of the International Standard Electric Corporation. These buildings, which are called buildings " I " and " H," have a total height from ground level to the roof of about 68 ft. The length of building " I " is 217 ft. by a width of 59 ft., and building " H " (which is at right angles to the other building), has a total length of 130 ft. by a width of 59 ft. These buildings have been erected on water-logged ground, and a special raft foundation had to be provided to keep the water out. The buildings comprise a basement and four floors with a flat roof. The ground floor has been calculated to carry heavy stamping machines. The upper floors, however, are of lighter construction sufficient to carry smaller machinery. The constructional work was carried out by Messrs. Hargot & Somers, Belgian contractors. The façade of the building is in cast stone and brick, but the structure itself is entirely in reinforced concrete. On the top of the roof are two water tanks for sprinklers and other purposes.

Concrete Piling, Ltd.

The principal works on which this firm has been engaged during 1926 are the following :

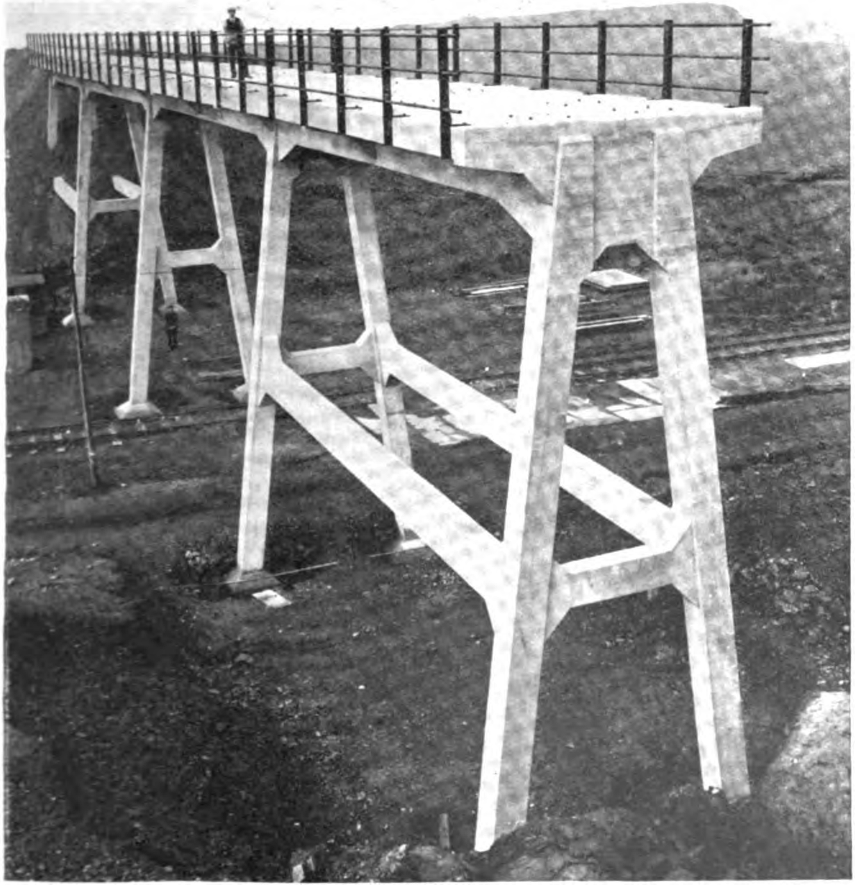
Reinforced concrete gas purifiers, for the Gas Light & Coke Co., at Beckton ; Coke and coal hopper, for the Gas Light & Coke Co., at Bow Common ; Docks and jetty for the Thames Steam Tug & Lighterage Co., at Brentford ; Sheet piling of river wall at the Waterworks of the Windsor Corporation ; Construction and driving upwards of 2,500 reinforced concrete piles for the foundations of the extensions of Barking Power Station and the construction of the superstructure for the new station. Two views are given of this piling work.

Considère Constructions, Ltd.

The following are some of the principal works for which Messrs. Considère Constructions, Ltd., have acted as Consulting Engineers for the reinforced concrete :

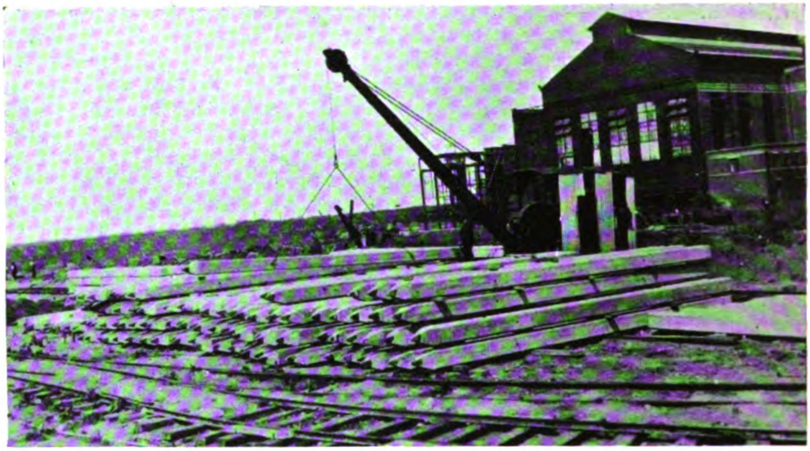
Footbridge at Morden.—The railway lines giving access to the new car sheds constructed by the Underground Railway Companies at Morden in connection with the extensions to the Hampstead & Highgate Tube, traverse a public footpath, and it was necessary to build a bridge, about 700 ft. long, with a ramp at each end, in order that pedestrians might cross the new lines. The Chief Engineer of the Underground Railways wished the bridge to be in reinforced concrete and of pleasing appearance, and the constructional depth was required to be as small as possible in order to minimise the length of the ramps at each end. The bridge has openwork parapets, which are treated as the main girders, the diagonal members in the parapet forming the shear members of the girders. The spans are in all cases about 70 ft.

Kelvin Hall, Glasgow.—The contract for the reconstruction of this Hall, which was destroyed by fire about two years ago, was placed by the Corporation in April last. The new building consists of four bays of vaulted roofing, which, together with the supporting columns, is entirely in reinforced concrete. There



[*R.C. Design by Edmond Coignet, Ltd.*

Crane Track at Glasgow.



[*Concrete Piling, Ltd., Contractors.*

Piling at Barking Power Station.

are three vaults of 110-ft. span, and one of 60-ft., and the total length of the building is about 600 ft. In spite of the difficulties consequent on the coal strike the contractors (Messrs. John Train & Co., Ltd., of Glasgow), have pushed the work forward with great speed and the building is now nearly complete.

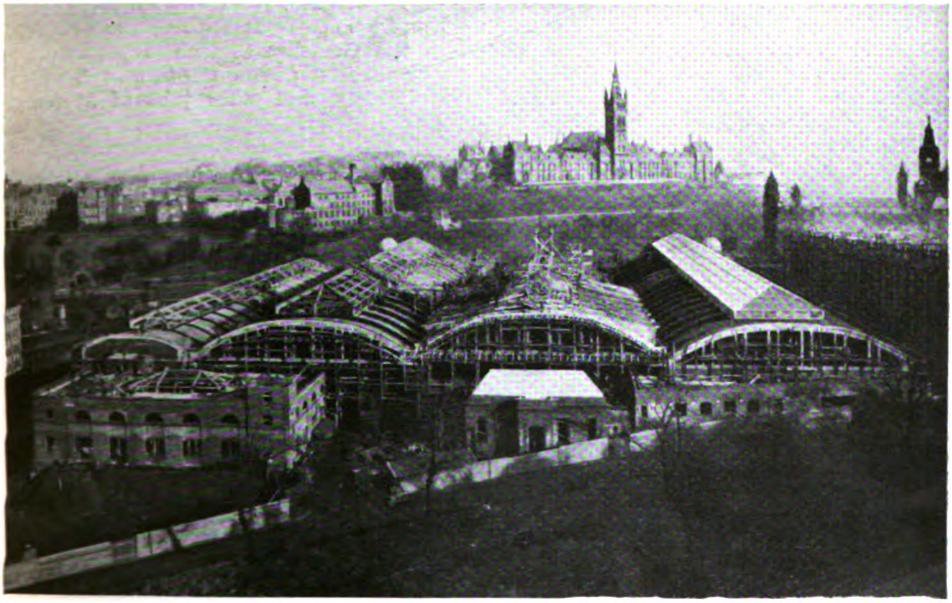
Building for Carreras, Ltd.—This well-known firm of tobacco manufacturers has placed a contract for the construction of what will be the largest reinforced concrete building in London. Some months ago they purchased a site at Mornington Crescent, N.W., and contracts were placed with Sir Robert McAlpine & Sons, Ltd., for the excavation and a reinforced concrete retaining wall. A further contract has now been given to the same firm for the superstructure. The joint architects are Messrs. M. E. & O. H. Collins and Mr. A. G. Porri. The building is one of the first attempts to treat the ornamental façade of a large building entirely in concrete, colour effects suitable to an

[*Concrete Piling, Ltd., Contractors.*

Piling at Barking Power Station.

Egyptian type of architecture being employed. The frontage of the building to Hampstead Road is nearly 600 ft., and the total area of floor space is nine acres.

Scarborough Harbour.—Some years before the war a scheme was prepared by the consulting engineer to the Scarborough Harbour Commissioners for the construction of a reinforced concrete wharf within the Harbour. This scheme was in abeyance for many years, but, the necessary facilities having been obtained, a contract for the construction of the wharf, which is about 495 ft. long, was placed with Mr. G. H. Gibson. The consulting engineer to the Harbour Commissioners is Mr. H. J. Paul, A.M.Inst.C.E.



[*R.C. Design by Considère Constructions, Ltd.*

Reconstruction of Kelvin Hall, Glasgow.

Factory at St. Helens.—The very large new works which the Nuera Art Silk Co. is building at St. Helens are entirely in reinforced concrete, including north light roofs of over 70-ft. span. The contractors are Messrs. Griffiths, Sons & Cromwell, Ltd., of Liverpool.

Empire Stone Co., Ltd.

The following are some of the contracts in course of construction or completed in 1926 on which Empire stone has been used :—

London.—Peter Robinson's Extensions, Oxford Street ; Holloway Arcade, Holloway Road ; Showrooms, Acton, for Messrs. Stewart & Ardern ; Premises, 100–102 Oxford Street ; Bouverie House, Fleet Street ; Offices, Upper Baker Street, for Abbey Road Building Society ; Extensions to Factory for Wanders Ltd., Kings Langley ; Flats, Knightsbridge Court, 49–50 Grosvenor Square and 48 Grosvenor Square ; Offices and Warehouse, Bridgewater Street and Bridgewater Square ; Royal Scottish Corporation Offices, Crane Court ; Offices, 31–33 Milk Street ; Clinic, Riseholme Street, Hackney ; Café Royal, Glasshouse Street ; Quadrant Arcade, Air Street and Glasshouse Street ; Regent Arcade, Argyll Street.

Contracts in the provinces include : Convalescent Homes, Skegness ; Secondary Schools, Swansea ; Bridges at Hall Place, Tonbridge ; Pumping Station, Prestwood ; 'Bus and Car Sheds for City Corporation, Nottingham ; Meat market, Nottingham ; New pumping station, Bilston ; "Ward Arms" Hotel, Dudley; Nurses' Home, Stafford; Court House, Rotherham; Offices and factory for Messrs. Kunzles, Queen's Hospital Extension, offices and factory for Messrs. Lucas, Ltd., premises, Besford Court Colony, and 'Bus Garage, Harborne, Birmingham; Picture House at Granby Street and Town Hall Square, offices for "Leicester Mail," and factory for B. Russell & Sons, Leicester; Weaving shed for Messrs. Courtaulds, Ltd. Leigh; Premises for District Bank, Walkden; Premises for Courtaulds, Ltd., Wolverhampton; Premises for District Bank, Old Colwyn; Picture House, Spalding; St. Andrew's Hospital, Northampton; Secondary Schools, Westcliff-on-Sea; Factory, Elland Road, Leeds; Mills for Messrs. G. H. Heath & Co., Macclesfield.

Among the contracts carried out by the firm in reinforced concrete are: Messrs. Formans' New Printing Works, Nottingham; Fire Station, Leicester; Factory for Messrs. T. & W. Farmiloe, Ltd., London; Open-air swimming pool at Tyringham House, Newport Pagnell, Bucks.

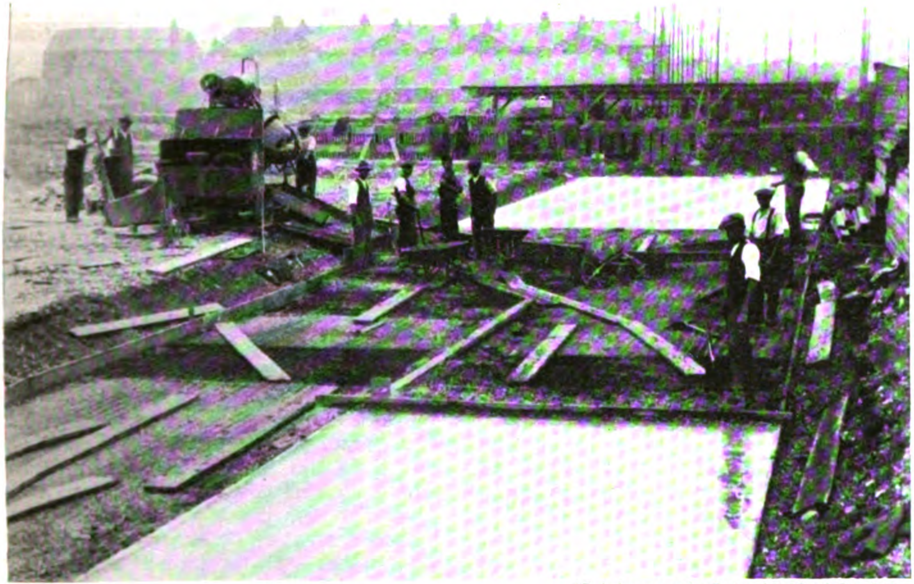
Evans Bros. (Concrete), Ltd.

This firm is now concerned mostly with pre-cast concrete and cast stonework, and in this connection has during the past year carried out cast stonework for various important buildings and to housing schemes at Doncaster, Ilkeston, Sutton, etc. In cast stone work of the larger size the firm has carried out the architectural dressings to a new church at Ambergate, the extensions of the Empire Theatre at Ripley, the dressings to the Greasley Church Institute, the new sports pavilion of the Sheffield University, and other jobs of a simiiar nature.

In the Engineering Department the firm has designed and supplied the reinforcing steel for retaining walls, floors, and flats to the new schools, Westhill,

[*Cast Stone by Empire Stone Co., Ltd.*

Conservative Club, London, S.W.



[*Reinforcement by Expanded Metal Co., Ltd.*

Foundation Rafts for Eastbourne Housing Scheme.

Torquay, for the Education Committee; for floors and flats for three schools for the Derbyshire Education Committee, one school for the city of Liverpool, and one for the Borough of Mansfield. The firm has also carried out complete a tunnel 142 ft. long in reinforced concrete at Haddon Hall.

Expanded Metal Co., Ltd.

Some of the more important works in which "Expamet" reinforcement has been used during 1926 include: Shardlow Reservoir, Borrowash; Retaining wall, Shepherds Bush, for Anglo-American Oil Co., Ltd.; Retaining wall, Almond Pow Burn, for the Burgh of Grangetown; Tang Wall Beck, Culvert, for City of York; Flooring, etc., at power station, Thorpe; Footings on housing schemes at Hoylake Common and Leeds; Foundations, flooring and roofing at Marton Grove Schools, Middlesbrough; Esholt Sewage Works for the City of Bradford.

Flooring and roofing at Messrs. Tetley's Brewery, Leeds; Foundations, flooring, roofing, etc., at Messrs. Terry's, Ltd., York; Flooring, etc., for Cadbury's, Ltd., Bournville; Foundations and flooring at Meanwood Hotel, Leeds; Holgate Institution, Middlesbrough; McVitie & Price's factory, Willesden.

Tramway sheds at Liverpool; Grosvenor Hall, Belfast; Flooring and roofing at Rialto Cinema, Liverpool; Sea wall, Western Beach, Dover; Vickers' factory at Weybridge; Flooring, etc., at Muckross Dominican College, Dublin; Superstructure for church at Lough Derg; Foundations to houses at Eastbourne; Foundations of Leys School, Cambridge; Sheet piling for Grand Junction Canal Co.; Lining to bunkers at Foleshill Gas Works; Foundations to purifier at Burnley Gas Works; Power station at Torquay; Paving at Electricity Station, Hull.

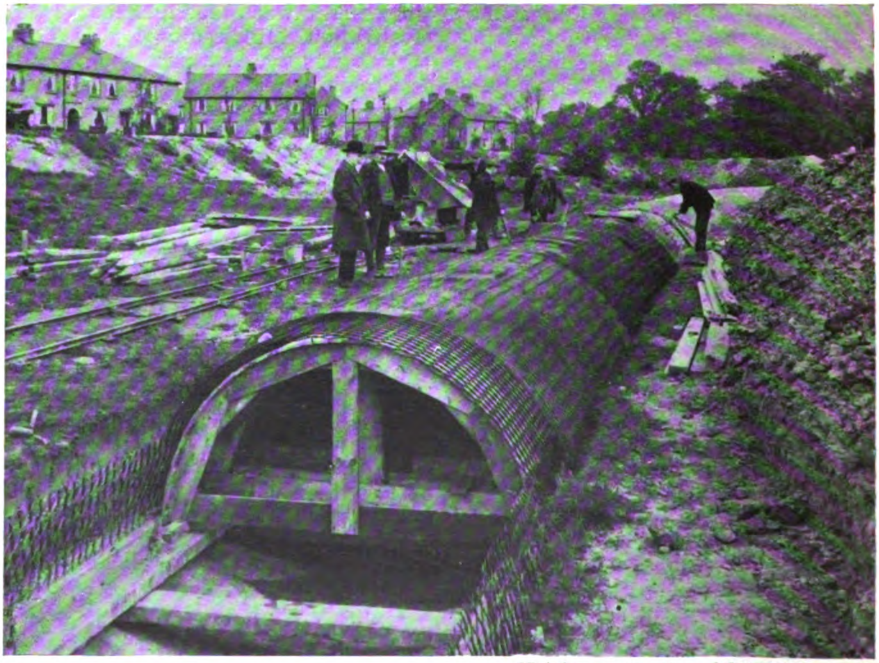
Flooring, etc., at the Pier Pavilion, Douglas, Isle of Man; Bank premises at Wisbech; Tank at margarine works, Liverpool; Fruit warehouse at York; Bathing pool at Margate; Flooring at Wath Main Colliery; Various concrete works for the Synthetic Ammonia & Nitrate Works, Haverton Hill; Foundations at the British Legion Factory, Richmond; Bridges and retaining walls at Longstanton; Bridge and dry dock at Jarrow-on-Tyne; Bridge at Smelt Hill, Allenheads.

Tang Hall Culvert.—This scheme consists of culverting a portion of Tang Hall Beck, which passes through part of the York Housing Estate. It is intended to fill up the low land crossed by the culvert (which is useless and liable to floods in winter) to the level of the bounding roads and utilise the space provided for allotments or recreation grounds.

The culvert is semi-circular, with a concave invert, and measures 5 ft. from top to bottom and 7 ft. from side to side. The base, which was constructed on soft foundations, was reinforced with No. 61 "Expamet" weighing 9½ lbs. per super yard, placed 2 in. below the invert at the centre. The arch is also reinforced with No. 61 "Expamet" placed 1½ in. from the intrados and 1½ in. from the extrados, the reinforcement being taken down to meet the horizontal reinforcement in the base. Stirrups of hoop iron bent to a **Z** shape were placed between top and bottom reinforcement in the arch at intervals of about 1 ft.

The reinforcement for the intrados and extrados of the arch was supplied in three pieces having 12 in. laps in the haunches, and was delivered on the site in sheets bent to the required contour ready for fixing into position. In this way all reinforcement was easily handled and quickly fixed. The line of the culvert differed from the winding course of the beck, necessitating about 4 ft. of excavation along its length.

The 6 to 1 Portland cement concrete forming the base was placed into position (on ashes) up to the horizontal reinforcement, which was pressed slightly into the concrete. Templates to the contour of the invert were then fixed 8 ft. apart and further concrete placed and screeded off. The slightly curved vertical haunch reinforcement was fixed into the concrete base, part of it being left standing out until the arch concrete was placed. The arch was constructed in lengths of about 50 ft., wood drum centres with surfaces treated with soft soap being used. The arch reinforcement was then fixed and the concrete placed into position and well tamped. All concrete was mixed by hand on a platform adjoining the



[*Reinforcement by Expanded Metal Co., Ltd.*

Tang Hall Culvert, York.

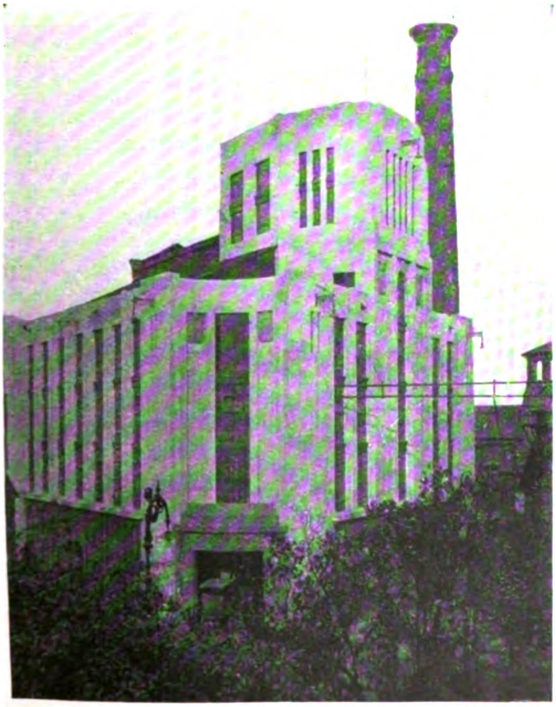
estate road, and conveyed to the required position on a jubilee track.

Three vertical shafts are provided along the culvert, and W.I. grids at each end. The total length is 300 yards, and the inclusive cost £3,160, which works out at £10 16*s*. per lineal yard. The work was commenced on March 1, 1926, and finished on September 21. About 18 men per week were engaged on the work. The City Engineer is Mr. J. W. Spurr.

F.C. Construction Co., Ltd.

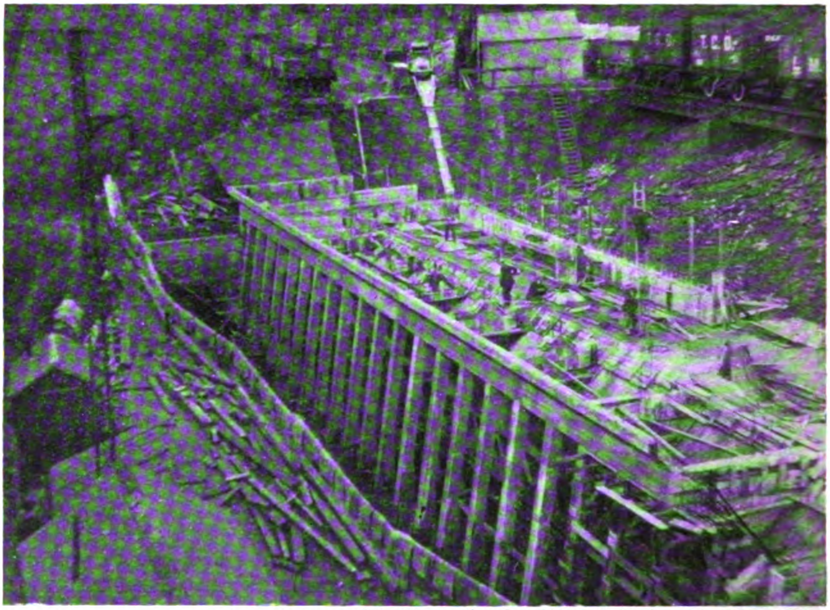
This firm specialises in the design and construction of buildings to accommodate plant used in the gas industry, and most of the work during 1926 has been carried out at gas works throughout the British Isles. Work completed or in course of completion during the year includes Gasholder slab foundations at Bognor, Chesterfield, Rayleigh, Brentwood, Darlington, Calverley and Worsboro' Dale; Purifier foundations have been constructed at Northwich, Stoke, Rugby, Goole, etc.; Water tanks are in course of construction at Sheffield and Nottingham, also railway gantries at the latter place; Bunkers have been completed at Oxford and Cardiff, whilst contracts have just been entered into for this class of structure at Tunbridge Wells and Harrogate; Foundations to 500 houses have just been completed at Derby.

A reinforced concrete ore bunker in Yorkshire to hold 4,000 tons of iron ore is now nearing completion. The opening took place in November last of the new boiler house for powdered-fuel boilers for the Derby Corporation. The reinforced concrete work includes boiler foundations, a hot well and a house, designed by the company to the instructions of Mr. A. Eaton, architect. A new sulphate house with foundations, tanks and subsidiary structures are being carried out to the design of the Company at Manchester, while work in hand also includes gasholder tank extensions in the Isle of Wight.



[Mr. A. Eaton, Architect; R.C. Design by F.C. Construction Co., Ltd.

Boiler House at Derby.



[*F.C. Construction Co., Ltd., R.C. Designers & Contractors.*

Ore Bunker in Yorkshire.

Gloucester Concrete Construction Co., Ltd.

During the past year this company has further developed its chief activity, the manufacture of architectural dressings and moulded work with an impervious surface closely resembling natural stone, and the plant has been further extended. Cast stonework has been provided for the following contracts amongst others during the year just completed :

Treherbert Hospital (Mr. W. D. Morgan, M.S.A., architect) ; Pontypridd Workmen's Hall (Mr. J. H. Davies, architect) ; Olympia Cinema, Bristol (James Pugsley & Son, contractors) ; Ilfracombe War Memorial approach and walling (Mr. F. B. Goodman, engineer and surveyor) ; Balustrading, walling and shelters for Barry U.D.C. (Mr. E. R. Hinchsliff, F.S.I., architect) ; Taibach Church (Messrs. Thomas & Morgan & Partners, architects) ; Sills, steps, grand stand and

[*By Gloucester Concrete Construction Co., Ltd.*

Cast-Stone Balustrade, in Cream Finish, at Whitmore Bay.

balusters, for the Chepstow Racecourse (W. T. Nicholls, Ltd., contractors); Rhymney Hall (Mr. Walter Rosser, architect); British Legion poppy factory flats at Richmond (Messrs. A. C. Thomas & Douglas Wood, architects); Officers' mess, Smallshot Camp, Aldershot (Sir Lindsay Parkinson, contractors).

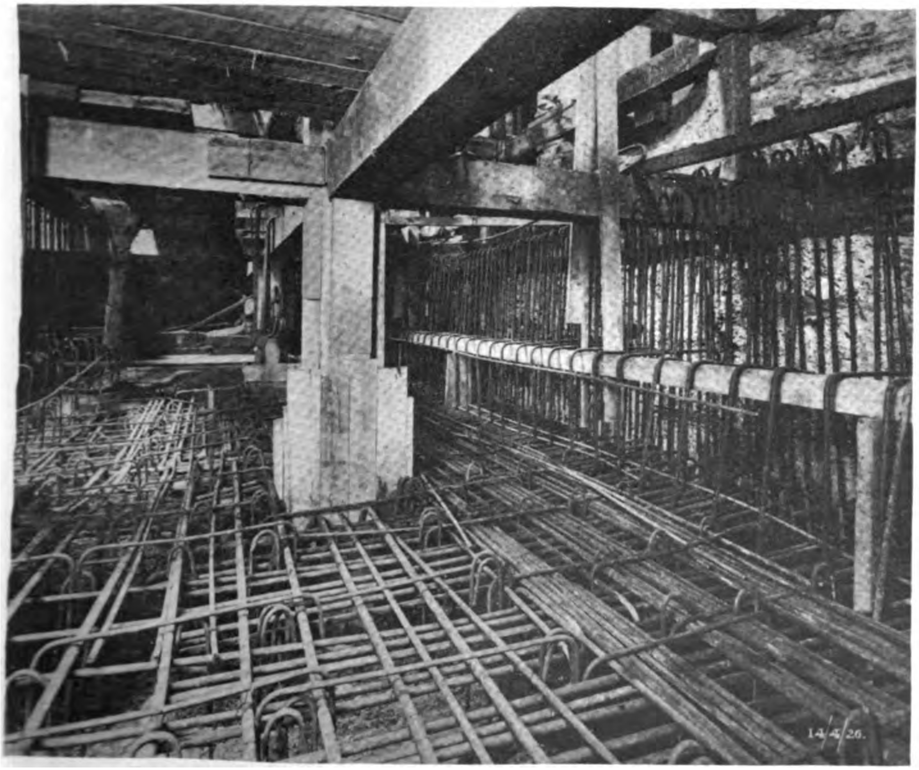
In addition, numerous contracts for housing schemes in various parts of the country have been carried out.

Holland & Hannen and Cubitts, Ltd.

A great deal of interesting reinforced concrete work has been carried out at the new Head Office of the Midland Bank, in Poultry. This work consists of many new and novel features, and gives a good illustration of what can be accomplished in a short time with reinforced concrete, especially when the work can proceed without the use of asphalt and produce the same results.

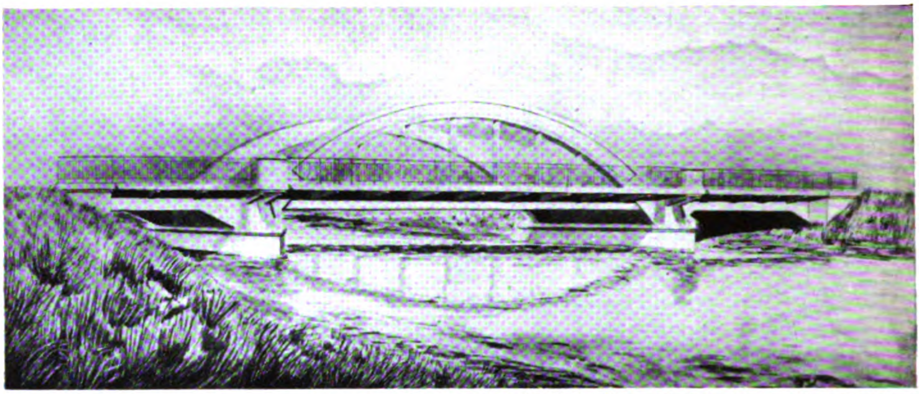
A reinforced concrete raft covers the entire site, and varies in thickness from 7 ft. 9 in. to 14 ft. 3 in. The concreting work of this raft and retaining walls was started on February 26, 1926, and the first structural steel was fixed on April 1, 1926, with the result that all was completed by November 3, 1926.

There are 103 ft. of retaining wall on the Poultry front to a depth of 43 ft. 7 in., 5 ft. thick at the base and 3 ft. at the top. There are 117 ft. of retaining wall in Grocers Hall Court to a depth of 59 ft. 4 in., 6 ft. at the base and 2 ft. 6 in. at the top. Under the London Joint Stock Bank has been erected a permanent wall 84 ft. long which serves the purpose of underpinning and is a division wall of the two sections of the building. This wall at the inside end runs under the old building a distance of 14 ft., and the method of accomplishing this feat is shown on the illustration.



[*Holland & Hannen and Cubitts, Ltd., Contractors.*

Foundation Work at New Head Office for the Midland Bank.



[*K. Holst & Co., R.C. Designers & Contractors.*

Reinforced Concrete Bridge at Welney.

There are also 260 ft. of temporary underpinning of adjacent buildings, which have been supported on R.S.J.'s backed up by a 12-in. slab of reinforced concrete. This method was used to simplify removal when the demolition of the buildings takes place for the new section, as the complete building is being erected in four sections.

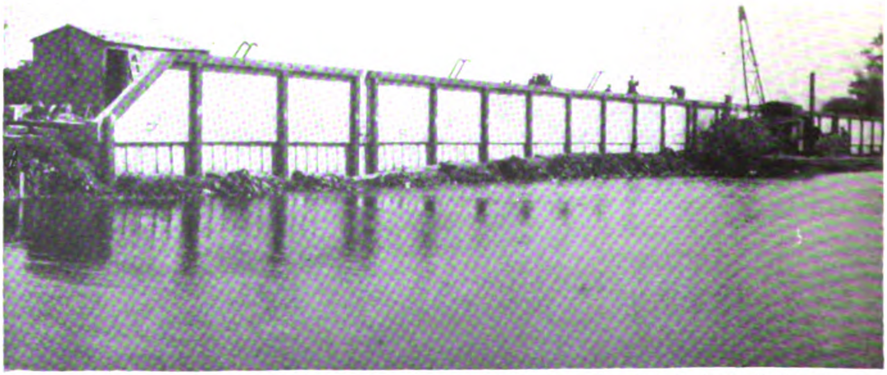
All the floor arches throughout are of heavy reinforced concrete minus 4 in. from the finished floor for the reception of electric conduits and floor finishes.

K. Holst & Co.

A large number of bridges and other works have been carried out by this firm during the past year, among the largest of which are the following:

The old suspension Bridge over the river Ouse at Welney is being replaced for the Norfolk County Council by a reinforced concrete structure 160 ft. long and 30 ft. wide, the centre span of 90 ft. being constructed as a twin arch with suspended decking, as illustrated.

The Lindsey County Council's Pilfrey Bridge has been reconstructed in reinforced concrete; the new bridge is 110 ft. long in four spans and 30 ft. wide between parapets. The approaches have necessitated retaining walls nearly 500 ft. long. Both of these bridges are built on piled



[*K. Holst & Co., R.C. Designers & Contractors.*

Wall on Grand Junction Canal.

foundations, and have been designed for the Ministry of Transport's standard loading.

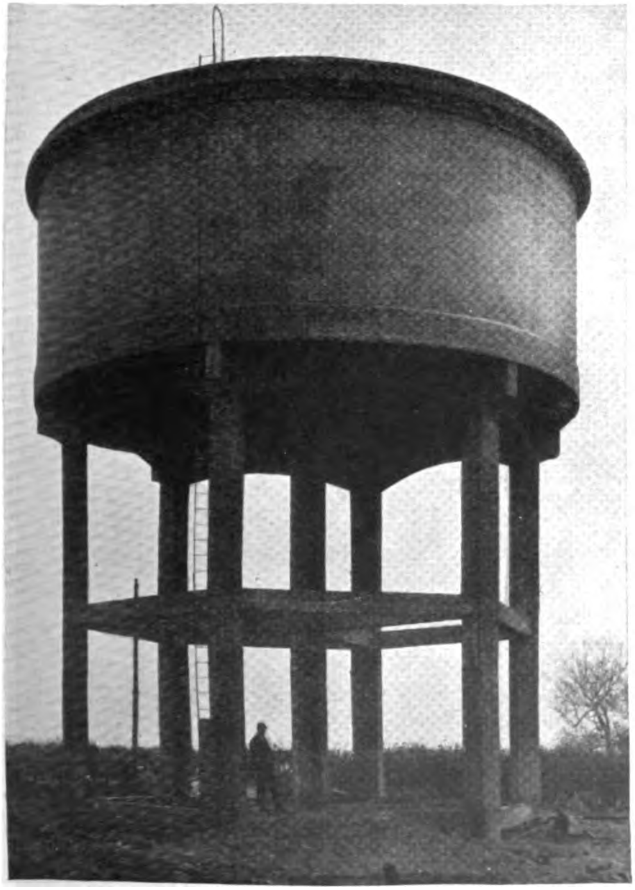
A viaduct, also designed for the Ministry of Transport's loading, is being built over the L.N.E. Rly. line at Tottenham. The total length of the viaduct, including the reinforced concrete approach slopes, is nearly 900 ft., and the centre span of 60 ft. crosses four main-line tracks.

Contracts for several smaller bridges in various parts of the country are also in course of execution. Approaches to a bridge over the L.M.S. Railway at Westcliff-on-Sea, consisting of reinforced concrete retaining walls 400 ft. in length and up to 25 ft. high, have been designed and built for the Southend Corporation, together with twelve shops and garages under the approach road.

Reinforced concrete wharves and sheet-pile walls 700 ft. in length and averaging 20 ft. high above the dredged level of the canal have been built on the Grand Junction Canal and the Limehouse Cut.

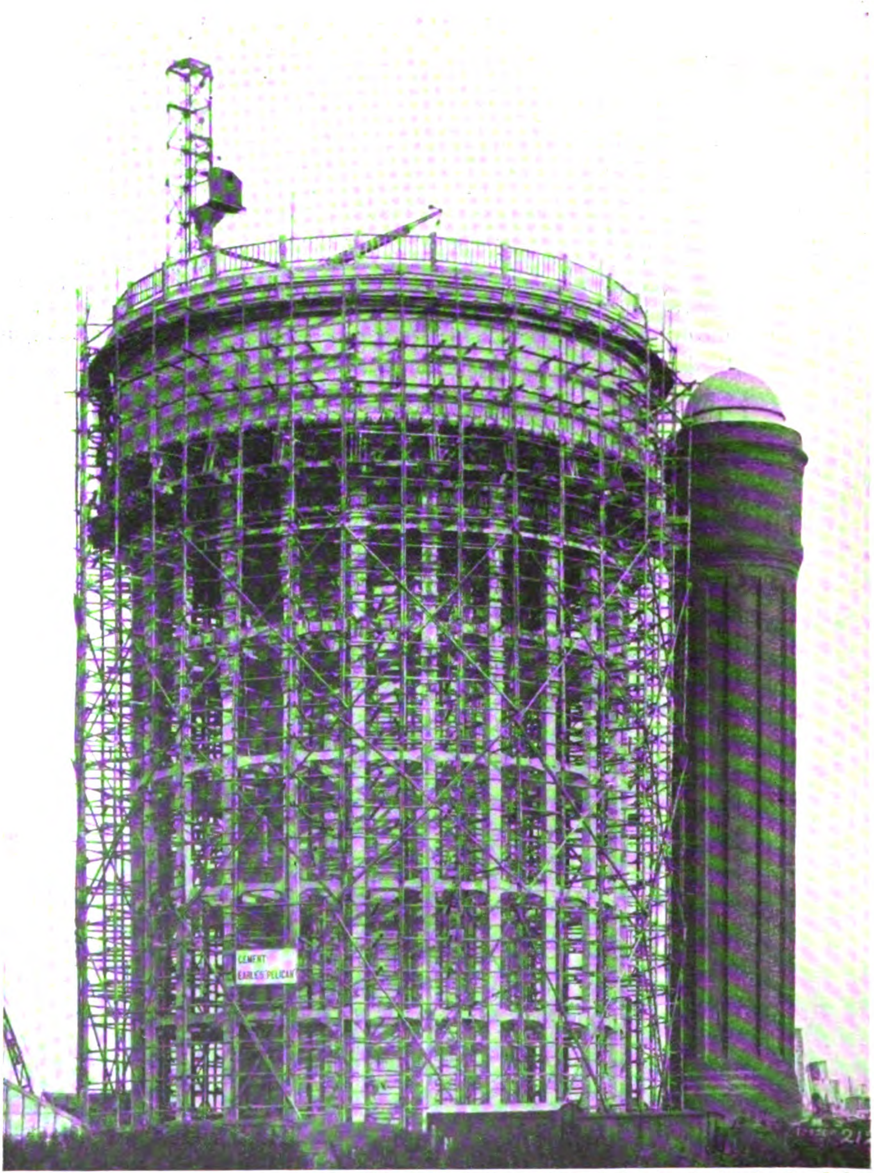
Piled foundations and rafts for a gasholder tank at Port Talbot, and a destructor works at Leamington Spa, have been designed and constructed, and a similar foundation is in hand for a new gasholder at Staines.

Reservoirs and tanks have been built in Lancashire and the eastern counties; an elevated tank at Windsor for the Borough Council; and a 120,000-gallon



[*K. Holst & Co., R.C. Designers and Contractors.*

120,000-gallon Water Tower at Woodside.



[R.C. Design by Indented Bar & Concrete Engineering Co., Ltd.

750,000-gallon Water Tower at Goole.

elevated tank at Woodville has been completed.

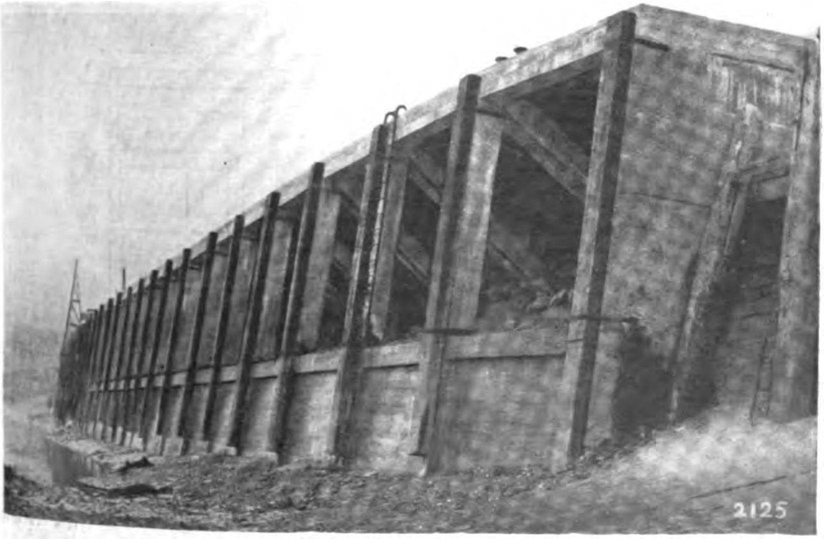
A large set of purifiers, consisting of eight boxes each 50 ft. by 36 ft., with an oxide floor and gantry over, and tar tanks of 4,000-tons capacity underneath, have been built for the Gas Light & Coke Company at a cost of over £20,000; other works for this Company include a set of overhead coke bunkers with outlets 40 ft. above ground level and a 1,000-gallon underground tar tank.

Indented Bar & Concrete Engineering Co., Ltd.

Amongst the more important works designed by this firm during the past year were the following: Warehouse at Staines, for the Linoleum Manufacturing Co., Ltd.; Warehouse at Wakefield, for Messrs. Paton & Baldwins, Ltd.; 750,000-gallon water tower at Goole, 145 ft. high (believed to be the largest in this country, and possibly in the world); Bridges at Sibsey, Swineshead, Felindre, Droitwich, and elsewhere; Filter beds at Egham; Quay at King's Lynn; 1,000,000-gallon reservoir at Uxbridge; Cellarage at Paddington, for the Great Western Railway; Store at Billingsgate Market, for the City Corporation; West Park Mental Hospital, Epsom, for the London County Council; and many schools for the Middlesex County Council and other authorities.

Amongst the more important works commenced during the year and still in course of construction, are the following: Bridge of the bow-string girder type (greatest span 110 ft., length 600 ft.); Orchestral piazza and bathing pool at Skegness; Grain silos at Ipswich; Cereal store at Nocton, Lincolnshire; Offices for the Holland County Council at Boston; Bridges at Colnbrook and Finchley, for the Middlesex County Council; School at Achimota, Gold Coast; Colonnade and dressing rooms, Norwich; Engine shed, Portadown, Ireland; Tramway depot, Sheffield; Sea wall at Blyth; 8-story factory at Staines, for the Linoleum Manufacturing Co., Ltd.; 4,500,000-gallon cooling pond at Southwick, for the Brighton Corporation Electricity Department; and a large number of schools.

All these works were designed by the Company in London, while branches in Australia, New Zealand, and South Africa have carried out a large number of structures, such as bridges, power stations, water towers, reservoirs, warehouses, silos, etc. The Company also controls the "Hollocast" concrete floor.



[R.C. Design by Indented Bar & Concrete Engineering Co., Ltd.

Boat Quay at Kings Lynn.

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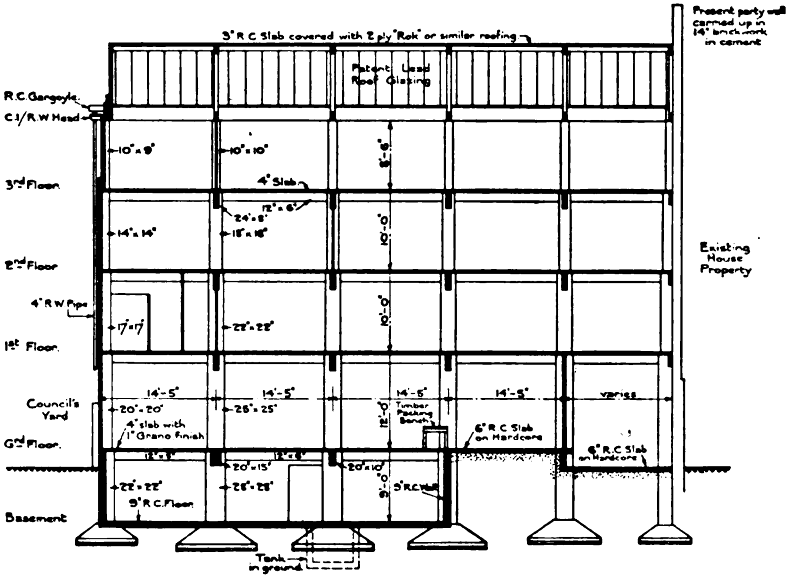
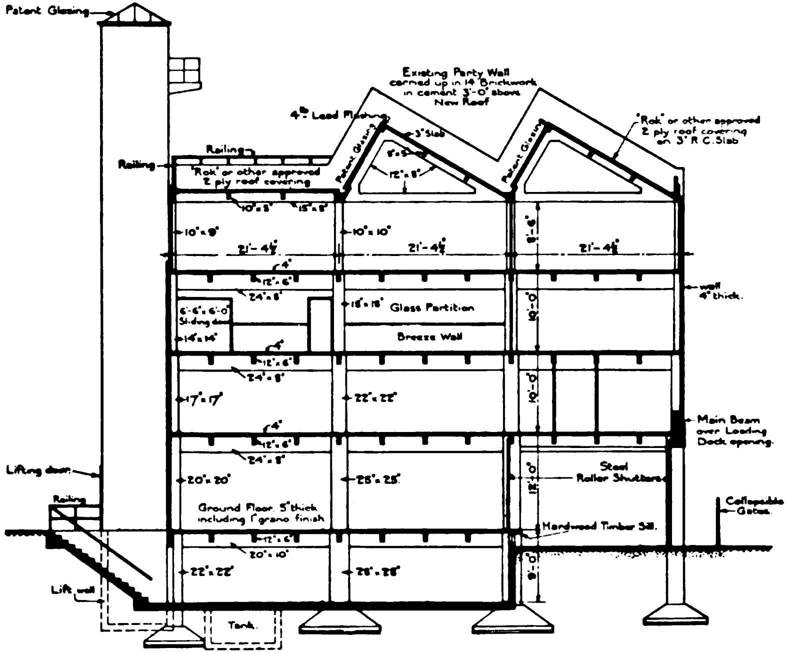


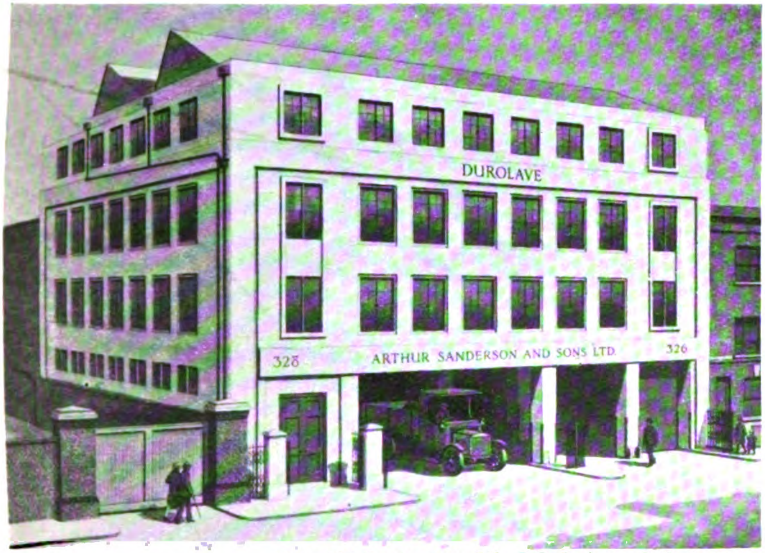
LONGITUDINAL SECTION



CROSS SECTION

WAREHOUSE.—326, KENSAL ROAD.

[*Industrial Constructions, Ltd., R.C. Designers & Contractors.*



[*Industrial Constructions, Ltd., R.C. Designers & Contractors.*

Warehouse at Kensal Road, W.

Industrial Constructions, Ltd.

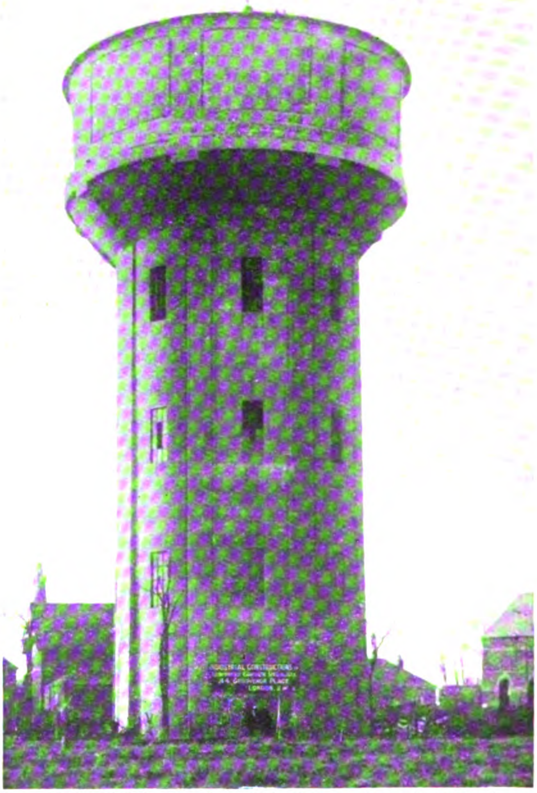
We illustrate here two of the many reinforced concrete works carried out by this firm in 1926. Another important work, a 10,000-ton coal bunker, is illustrated and described elsewhere in this number.

Warehouse at Kensal Road, W.—This contract comprises the building complete in every respect, including demolition of old buildings, excavations, reinforced concrete work, internal fittings, lift and lift enclosure, patent glazing to roofs, and the alterations to existing property to conform with the London Building Act. The building is composed of reinforced concrete throughout and has been designed in accordance with the L.C.C. regulations. The building has a frontage of 72 ft., a depth of 64 ft., a height from ground level of 45 ft., and comprises basement, ground floor, and three floors above, with a flat roof over one-third of the area and north light roof over the remainder. The concrete is composed of 4 parts of crushed ballast to 2 parts of coarse sand to 1 part of Portland cement. The reinforcement throughout consists of mild steel bars complying with the B.S.S. for mild steel.

The ground floor is finished with 1 in. of granolithic which was laid within 24 hours of concreting the floor slab. In order to secure the best effect and avoid rendering, the shuttering to the principal elevations is being glued up with watertight glue and planed off where necessary. The building is being erected in two parts, the three left-hand bays shown in the longitudinal section being completed first.

The work was commenced on August 20, 1926, and the first floor is now concreted. The first portion of the building will be finished within seven to eight months of its commencement. The building is being erected for Messrs. A. Sanderson & Sons, Ltd., wallpaper and paint manufacturers, and is to be used for loading and unloading materials, the manufacture of paint and the storage of finished products. Part of the first floor has been reserved for office accommodation and the basement is to accommodate the large gas engine driving the plant, etc.

200,000-*Gallon Water Tower, Skegness.*—This contract was secured in open competition, and is now practically completed within the contract time of seven months. The engineer for the water tower and the attendant works is Mr. Percy Griffith, M.Inst.C.E., M.I.M.E., of 39 Victoria Street, S.W.1.



[Industrial Constructions, Ltd., R.C. Designers & Contractors.

Water Tower at Skegness.

The height from ground level to the highest water level is 90 ft.; the total height of the water tower is 103 ft. 9 in.; the inside diameter of the tank is 50 ft.; and the inside diameter of the supporting tower is 36 ft. The foundations consist of a reinforced concrete raft composed of a beam underneath the walls, a circular slab between the walls, and a cantilever footing outside the walls. The supports to the tank consist of a cylinder having a door at ground level and windows at different heights, as shown in the photograph. The bottom of the tank between the walls is a dome, and the portion outside the walls is conical in form. The tank walls rise vertically from the extremities of this conical bottom. The flat roof is supported by the outside walls of the tank and by the walls of a cylinder passing through the centre of the tank, giving access to the roof.

The structure throughout is composed of concrete, reinforced with mild steel bars. The shuttering for water towers of this description is difficult and expensive, but the whole of the work went through smoothly without a hitch. A fact worthy of note is that after the concreting of the tank commenced it was proceeded with continuously. This involved the erection of practically all the shuttering and steel reinforcement before concreting commenced, and, although it added considerably to the shuttering difficulties owing to wind pressure in such an exposed spot, it had the advantage of minimising the difficulties so often experienced where an endeavour is made to join new concrete to concrete which has already become hard.

A. Jackaman & Son, Ltd.

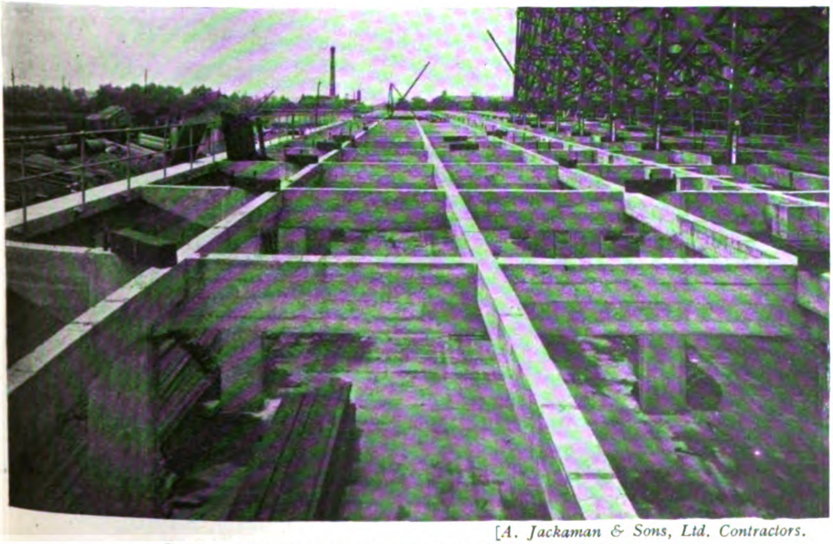
Super Generating Station at Birmingham.—A small section of this large contract is illustrated in the photographs which show the cooling ponds. These ponds accommodate forty-five cooling towers and cover an area of from three to four acres. They constitute an immense range of reinforced concrete tanks entirely supported on piles, the floors and walls being of comparatively thin beam and slab construction. The framework for carrying the towers is shown in the photographs, and an interesting reinforced concrete cantilever canopy along one side of the work to protect the timber towers from the sparks thrown from passing trains.

Deep Water Jetty at Northfleet.—The rapidly increasing manufacture of cement on the Thames, which now employs some of the most up-to-date and extensive plant in the world, has necessitated the provision of new deep-water accommodation for ships at the new Bevans Works of the Associated Portland Cement Manufacturers, Ltd., at Northfleet. This consists of an island jetty 600 ft. long and 40 ft. wide running parallel with the river bank, with berthing accommodation for 5,000-ton ships at all states of the tide. The work, which is now completed, is an excellent example of up-to-date reinforced concrete construction. The wharf, which we hope to describe fully later, carries electric cranes and conveyor plant of the most recent type for rapid and economical handling of cement.

Wharf and Sheds at Royal Victoria Dock.—This extensive contract for the Port of London Authority is now complete and ready for traffic. As shown in the photographs, it comprises a reinforced concrete wharf about 750 ft. long with transit sheds of steel-frame construction, extensive areas of sidings, and reinforced concrete roadway. The building of the wharf was expeditiously carried out, as may be gauged from the fact that it includes 68 large cylinders which can be seen through the fendering in the photographs, and the period between the sinking of the first and last cylinders was but little over four months.

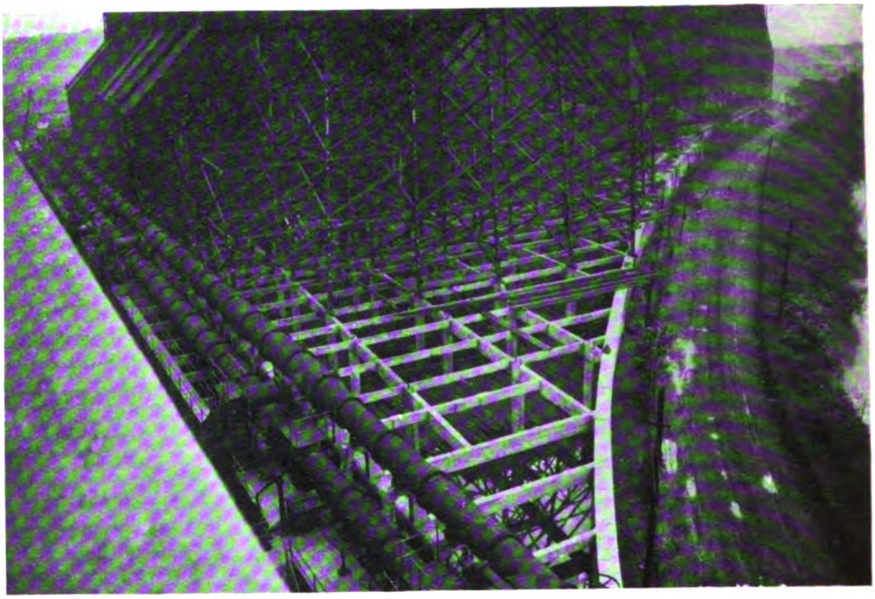
Engine Sheds at Exmouth Junction.—The photograph shows a 62½-ton test in the lifting bay, which has recently been completed. The sheds cover about two acres and are a good example of what can be done with reinforced concrete frame construction filled in with concrete block walls and pre-cast roof slabs. Roof principals of considerable span were also pre-cast. The smoke chutes, of which there are a large quantity, are made of thin reinforced concrete.

Wharf at Chelsea Creek.—This recently

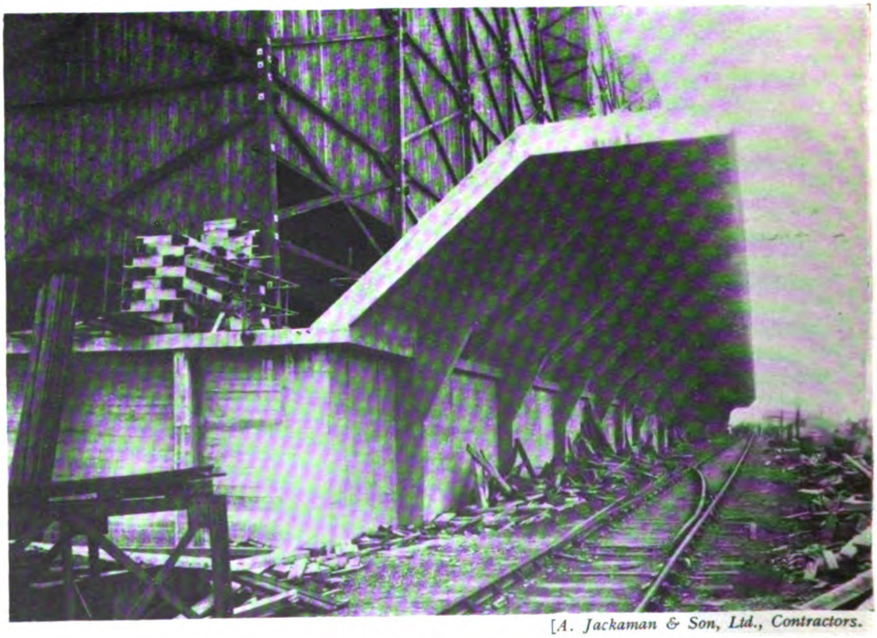


[*A. Jackaman & Sons, Ltd. Contractors.*

Super-Generating Station at Birmingham.



Framework for Cooling Towers.



[A. Jackaman & Son, Ltd., Contractors.

Concrete Canopy at Super-Generating Station, Birmingham.

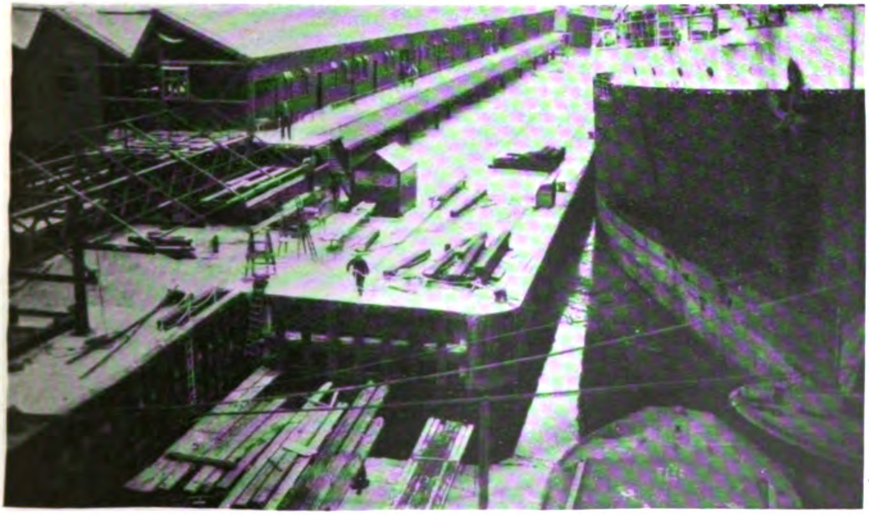
[A. Jackaman & Son, Ltd., Contractors.

Meat Trade Accommodation at Royal Albert Docks.

completed 830 ft. wharf for the Great Western Railway, has greatly improved the accommodation for barges in Chelsea Creek. It consists of a reinforced concrete wall and relieving platform supported on king piles and a line of reinforced concrete sheet piles throughout the length of the wharf.

Johnson's Reinforced Concrete Engineering Co., Ltd.

From among the structures designed by this firm during the past year we illustrate the headgear, heapstead and gantry buildings at Arley Colliery, Warwickshire, and the bridge over the river Severn at



[A. Jackaman & Son, Ltd., Contractors.

Meat Trade Accommodation at Royal Albert Docks.

Dolwen. The bridge, which was designed for the Newtown and Llandilos Rural District Council under the direction of the Surveyor, Mr. Thomas Humphreys, has a total length of 140 ft., with end spans of 39 ft., and a centre span of 62 ft. The roadway is 18 ft. wide and the footpaths 3 ft. 6 in.

John Laing & Son, Ltd.

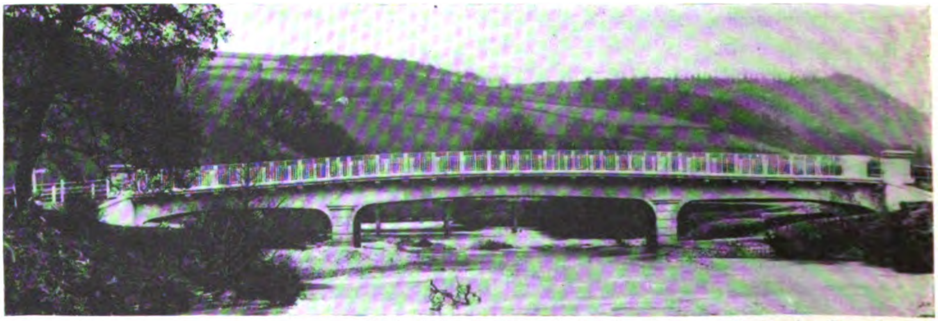
During 1926 houses on the " Easiform " system of concrete construction have been built as follows :

Gosport : Scheme for 122 houses under the Borough Engineer, Mr. E. J. Goodacre. A further 198 houses at present in course of construction.—Hayes : Sixty houses under Mr. T. Alwyn Lloyd, F.R.I.B.A.—Plymouth : Scheme of 84 houses for the Gt. Western Railway Co., under Mr. T. Alwyn Lloyd, F.R.I.B.A.—Woolwich : Contract for 500 houses started, for the Metropolitan Borough of Woolwich.—Tottenham : Contract for 300 houses started, for the London County Council.

Other reinforced concrete works in which the firm is interested include : St. Nicholas Bridge, Carlisle, which has a considerable amount of concrete embodied in its construction.—Carr's factory, Carlisle : New extension in concrete with brick veneering.—New premises for Messrs. Robinson Bros., Ltd., Carlisle, with concrete floors and roof, and everything of concrete except the veneering. Mr. H. Foxall, L.R.I.B.A., is the architect.—Officers' Mess, Catterick, Yorks : Constructed solely in concrete with the exception of the veneering. Carried out for the War Office. There are quarters for 30 officers and servants, etc. This is one of the buildings comprising a contract amounting to approximately £500,000. The work entailed housing about 1,000 of the firm's own staff in isolated, moorland country. For a large number married quarters were provided, together with schools, hospitals, and libraries.

[A. Jackaman & Son, Ltd., Contractors.

Engine Sheds at Exmouth Junction. (62½-Ton Test in Lifting Bay.)



[R.C. Design by Johnson's Reinforced Concrete Engineering Co., Ltd.

Bridge over the Severn at Dolwen.

Peter Lind & Co.

A reinforced concrete bridge designed and constructed by this firm for the Norfolk County Council was opened for traffic at Stow on August 28 last. The total length is 326 ft. and the overall width 30 ft., providing a 20-ft. carriageway and a 4-ft. footpath on one side. The structure is supported on 60 reinforced concrete piles 14 in. square by 40 ft. long, driven to 30 ft. below Ordnance Datum, giving a total height of 75 ft. from the point of the pile to the top of the middle arch. The central arches have a span of 93 ft. 6 in. and the end spans 63 ft. 9 in. each.

Another important bridge recently completed by the firm is for the Middlesex County Council, and spans the District Railway at Sudbury. In this case the whole of the reinforced concrete details were prepared by the Trussed Concrete Steel Company. The bridge has a width of 80 ft. between parapets and its total length, including approaches, is approximately 210 ft.

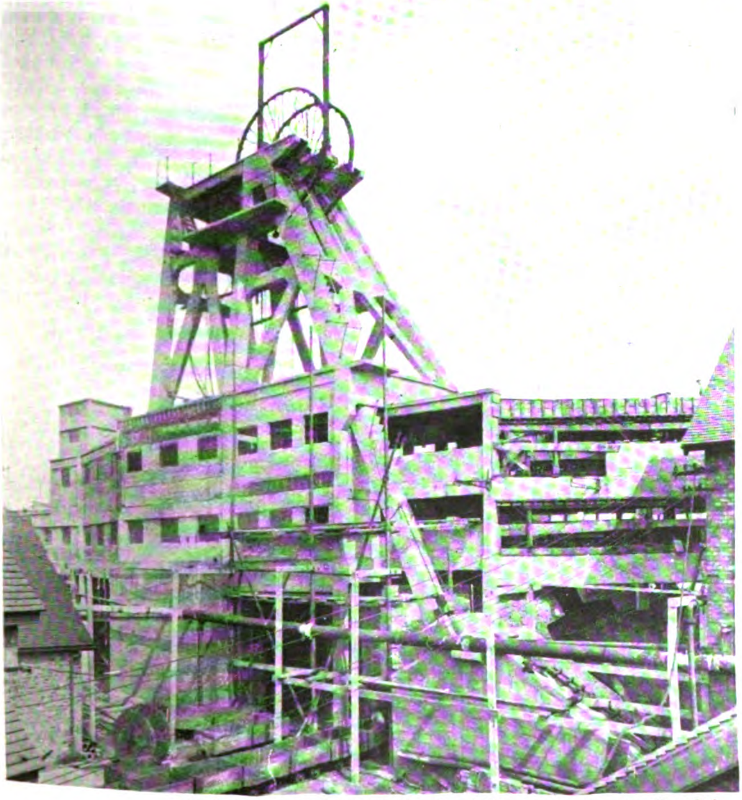
The buildings at Fulham for the Gas Light & Coke Company, mentioned in our last New Year Number, are now nearing completion.

The most important contract secured by the firm in the early part of 1926 was for the erection of new works at Stoke-on-Trent for the Michelin Tyre Company. The value of this contract is considerably over £300,000, and includes :—

(1) Several single-story buildings covering an area of 400,000 sq. ft.

(2) A multi-story reinforced concrete building with 45,000 sq. ft. floor area.

(3) A boiler and power house with over-



[*R.C. Design by Johnson's Reinforced Concrete Engineering Co., Ltd.*

Headgear, Heapstead, and Gantry at Arley Colliery.

[John Laing & Sons, Ltd., Contractors.

Concrete Houses in Cumberland.

head coal bunker in reinforced concrete, accommodating four boilers.

(4) A building containing nine underground petrol storage tanks.

(5) A reinforced concrete enclosure wall 10 ft. high by 3,000 yds. long.

(6) 20,000 sq. yds. of roads.

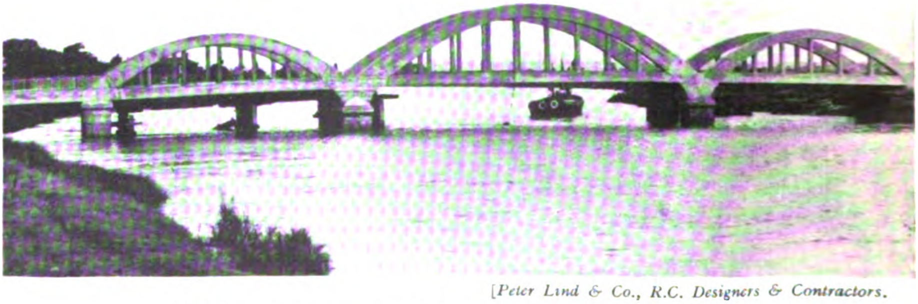
(7) All necessary rainwater and soil drains, as well as all sanitary arrangements.

(8) Reinforced concrete elevated water tank 120 ft. high (capacity 44,000 gallons).

(9) Reinforced concrete pile foundations and beams.

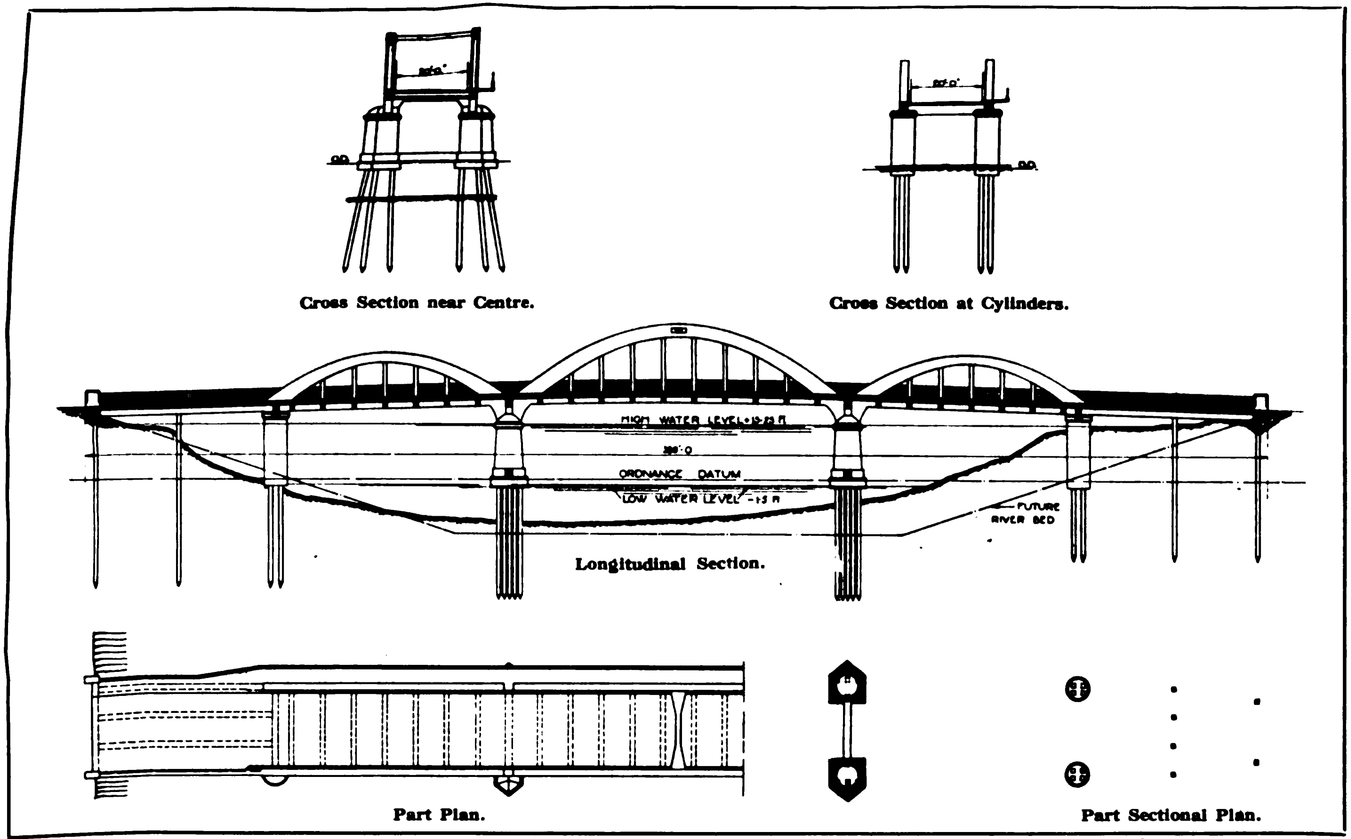
This contract is being carried out in collaboration with Messrs. Saxild & Partners, of Westminster.

Other contracts secured during the past year are foundations for turbo-alternators for the Corporations of Wimbledon, Eastbourne and Darlington; piling for buildings and gas holder in connection with new C.W.S. plant; concrete work at Morriston Gas Works; piling foundations for a gas holder at Poplar; concrete roads at Crewe Loco Works; switchgear gantry at Brimsdown Power Station; ash hoppers at Nine Elms Gas Works; grain silos (200,000 bushels capacity) at Welwyn for the Shredded Wheat Co.; power house foundations at Staines; reservoir



[Peter Lind & Co., R.C. Designers & Contractors.

Bridge at Stow, for the Norfolk County Council.



Cross Section near Centre.

Cross Section at Cylinders.

Longitudinal Section.

Part Plan.

Part Sectional Plan.

[Peter Lind & Co., R.C. Designers & Contractors.

Stow Bridge, for the Norfolk County Council.

(capacity 500,000 gallons) for Trowbridge Water Co.; piling foundations at Purfleet and Beckton.

Liverpool Artificial Stone Co., Ltd.

We illustrate some examples of the very fine cast stone made by this Company during the past year. In addition to these ornamental pieces, the firm specialises in pre-cast units for architectural purposes, and a building on which these have been used is also illustrated. The works has now been extended to a capacity of 4,000 cu. ft. of architectural dressings and 3,500 super yards of paving flags per week, in addition to the usual building units and ornamental pieces. During the past year the company delivered well over 100,000 super yards of granolithic paving flags. The list of buildings on which the firm's cast stone has been used is a very long one; it ranges from important city buildings and large factory buildings to housing schemes, and includes war memorials, hotels, banks, theatres, public buildings, hospitals, and churches, to the specification of well-known architects.

L. G. Mouchel & Partners.

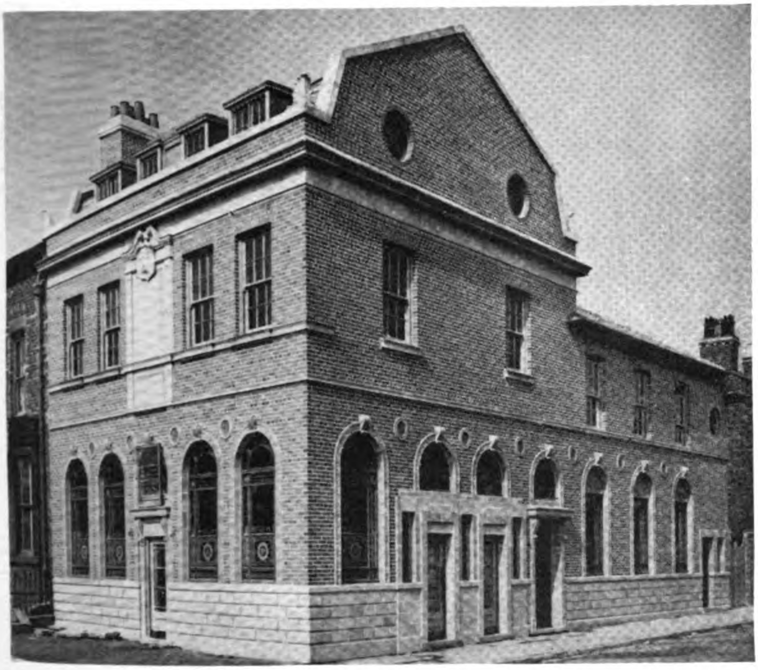
One of the principal works in progress to the reinforced concrete designs of Messrs. Mouchel & Partners is the new Border Bridge at Berwick-on-Tweed. This is the largest reinforced concrete bridge so far undertaken in the United Kingdom. The old 15-arch stone bridge, dating from 1634 and measuring 924 ft. long by only 17 ft. wide, proved totally inadequate to cope with modern traffic. The new bridge is planned to take the through main-road traffic, and is being constructed on a site well adapted to the formation of good approach roads and avoiding narrow streets at each end. The old stone bridge will be preserved and used for purely local traffic between Berwick and Tweedmouth.

The new bridge, with a length of 1,405 ft., will be carried on five main piers and will comprise four arch spans and two straight girder approach spans. The arches increase progressively in length from the southern approach, their spans being 167 ft., 248 ft., 285 ft. and 361 ft. 6 in. from centre to centre of the piers. The southern approach, with four continuous girder spans, will be 199 ft. in length, and the northern, with two similar spans, will be 144 ft. 6 in. long. Measuring 46 ft. wide between parapets, the new bridge will be about 2¾ times the width of the old structure, which has for so long constituted a serious hindrance to traffic on the main highway to the North.

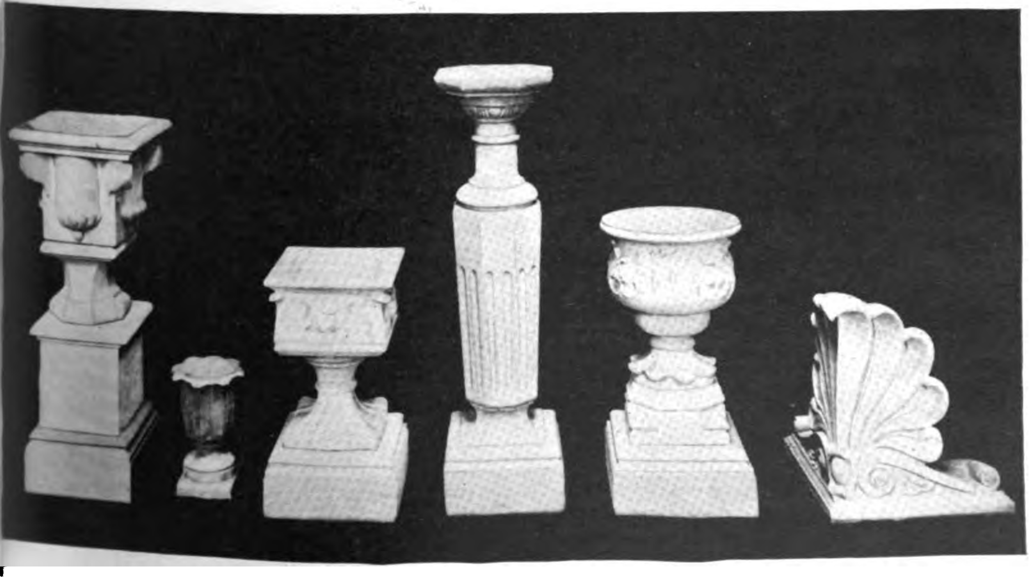
Preliminary work was started in December, 1924, in readiness for the commencement of excavations early in 1925. Good progress has been made throughout, and

[*Peter Lind & Co., R.C. Designers & Contractors.*

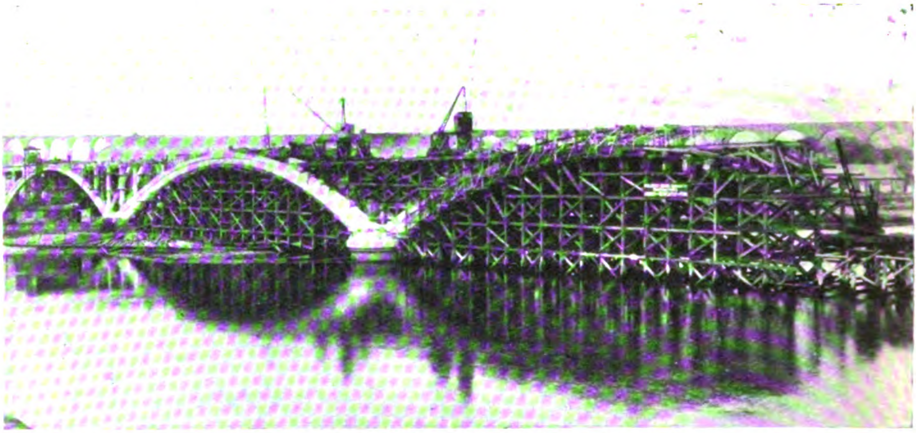
Stove and Meter Shops at Fulham nearing Completion.



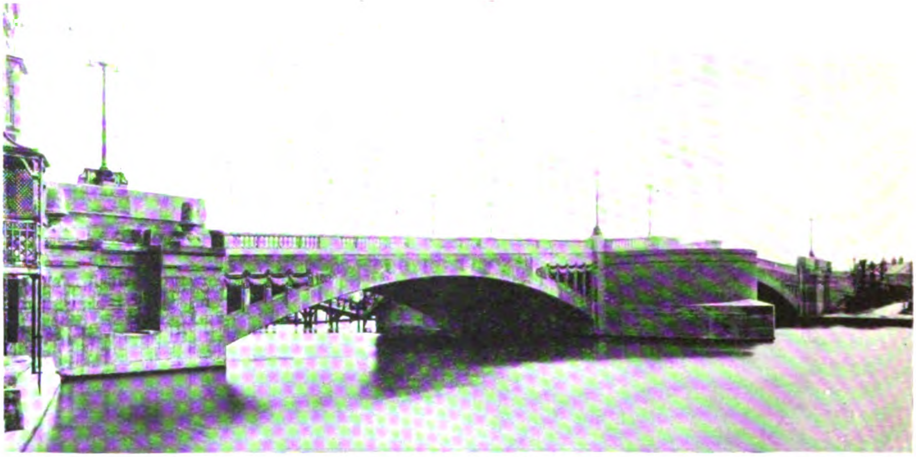
Anfield Hotel, Liverpool.



Cast Stone by the Liverpool Artificial Stone Co., Ltd.



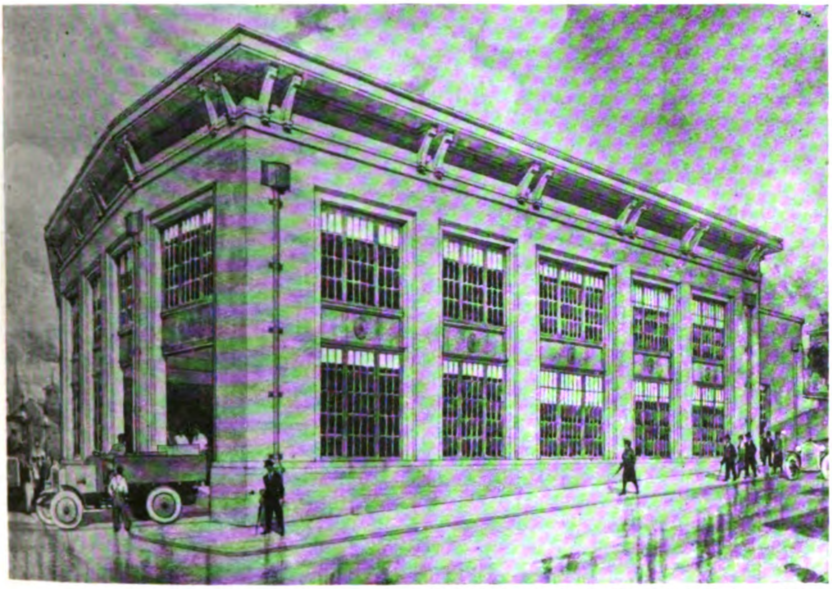
New Border Bridge, Berwick-on-Tweed.



Caversham Bridge.

[*R.C. Design by L. G. Mouchel & Partners, Ltd.*

Little Hereford Bridge.



[R.C. Design by L. G. Mouchel & Partners, Ltd.

Central Stores, Wakefield.

the last span is now in course of construction.

Other structures designed by this firm, so far as the reinforced concrete details are concerned, include :—

Bridges.—Caversham Bridge (arch rib type; two spans 126 ft. 4½ in. and 106 ft. 4½ in. respectively); Kirkcudbright Bridge (bowstring girder type; five spans 88 ft. 9 in. each); Bow Bridge, Rotherham (arch rib type; one span of 58 ft. 6 in., with a width of 70 ft.); Mights Bridge, Southwold (straight girder type: three spans of 26 ft. 8 in. each); Allestree Bridge (arch rib type; one span of 100 ft.); Briardale Road Bridge (vaulted arch type; one span of 49 ft.); Drip Bridge, Stirling (arch rib type; two main spans of 70 ft. each, with flood arch on the Stirlingshire side); three Bridges for the Surrey County Council: Over Guildford Line, Southern Railway (straight girder type on piles; two spans of 32 ft. each); Over Main Line, Southern Railway (straight girder type on piles; five spans of 17 ft., 56 ft., 42 ft. 42 ft. and 17 ft.); Over the Epsom Line, Southern Railway (straight girder type on piles; three spans of 70 ft., 48 ft. and 40 ft.); Little Hereford Bridge (arch rib type, with a span of 110 ft.); Hertford Bridge (straight girder type; three spans, the centre span being 40 ft. and the two end spans 24 ft. 9 in. each; width between parapets 49 ft. 9 in.); Stone Bridge, Aylesbury (straight hollow girder type; two spans of 21 ft. each); Egginton Bridge (arch rib type, with one span of 123 ft. and approach viaducts 150 yds. in length, in spans of approximately 15 ft. each); Larbert Bridge (arch rib type; 98 ft. span); bridge at Watford (straight girder type; five spans of 30 ft. each, width between parapets 70 ft.).

Other structures include: Chichester Reservoir (1,000,000 gallons capacity, with counterfort type of walls and flat roof); Nork Reservoir, for the Sutton Waterworks (4,000,000 gallons); Lamberhurst, Exedown and Hastingleigh Reservoirs (500,000 gallons each); Lodge Hill Reservoir (800,000 gallons); Epsom Reservoir (2,000,000 gallons); reservoir, Burgh Heath, Banstead (2,000,000 gallons); Kimberworth Reservoir, Rotherham (2,000,000 gallons); Water Tower, Ilkeston (600,000 gallons; octagonal design).

Albert Wharf, for the Corporation of Newcastle-on-Tyne; Londonderry Wharf for the Londonderry Port & Harbour; jetties at Bristol, for the Imperial Tobacco

Co.; Nechells Generating Station, Birmingham (foundations, etc.); engine sheds, Ramsgate, for the Southern Railway; cooling towers for the Liverpool and Leicester Corporations; Grandstands at Trent Bridge, for the Nottingham County Cricket Club (standing and seating accommodation for 6,000); Grandstand, Ballsbridge, Dublin (seating accommodation for 2,000); Grandstand, Lansdowne Road, Dublin.

New Fire and Police Station for the Bristol Corporation; new Central Stores for the Wakefield Corporation; warehouse at Newport, for the Great Western Railway; Georgian Buildings, Cardiff; public baths, for the Newcastle Corporation; extensions to Penarth Esplanade and Pier.

Nott Brodie & Co., Ltd.

The principal works completed during 1926 are the following:—

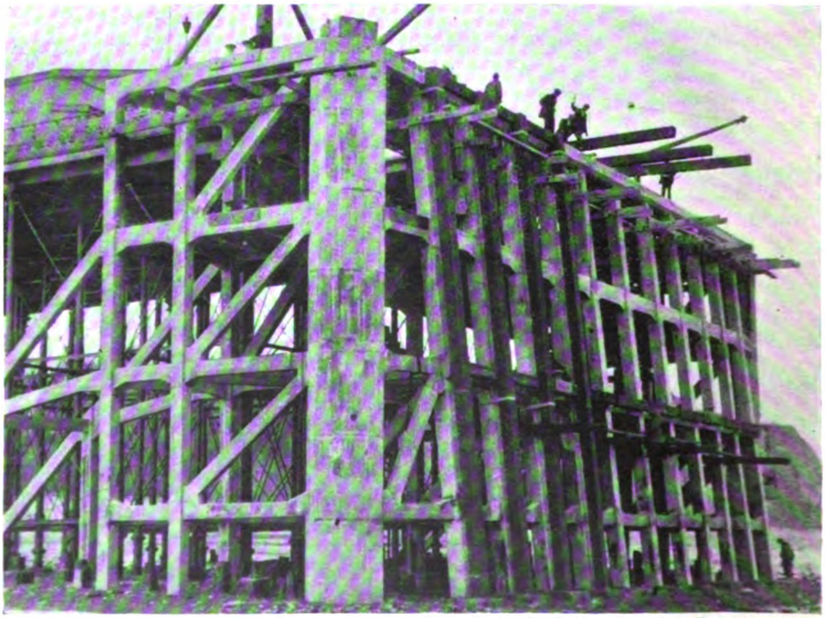
Four contracts for the Bristol "Portway," comprising the road formation, including nearly 400,000 cu. yds. of excavation, mostly rock; heavy skew bridge over the railway, requiring abutments about 140 ft. long with foundations down to 50 ft. below rail level; viaduct across the Trym Valley, having six spans of 46 ft. 6 in. each founded on concrete monoliths to a depth of 55 ft. below ground level; the construction of a viaduct between the river and the cliff, having 13 spans of 30 ft., with reinforced concrete slab superimposed.

Other contracts include: The cut and foundations for the Seacombe landing stage, which is believed to be the largest work of its kind; the Chepstow Racecourse; reconstruction of the Arrow Fuel Wharf, Newport, Mon.

The firm is at present engaged on the construction of a wall across Glentworth Bay at Weston-super-Mare. This will be built with ferro-concrete caissons constructed on the shore and floated into position on to foundations previously prepared, and will have sufficient valves to retain the tide or allow it to recede.

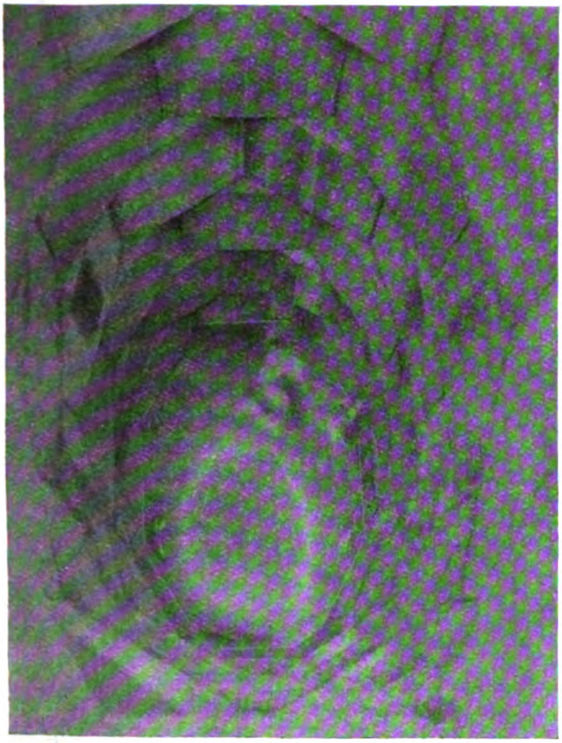
Perry & Co. (Bow), Ltd.

The new Post Office at Singapore is the largest building in Singapore. It will have eight stories including the basement, and is built of reinforced concrete faced with cast granite. It will house the Post Office, the Singapore Club, the Master Attendant's Office, and other Government



[R.C. Design by L. G. Mouchel & Partners, Ltd.

Pierhead at Penarth.



[Nott, Brodie & Co., Ltd., Contractors.

Trym Viaduct: Looking down one of the Concrete Monoliths.

offices. The architect is Major Keyes. The cost of the building is estimated at four million dollars.

The Sailors' Home at Singapore has now also been completed entirely in reinforced concrete to the design of the same architect.

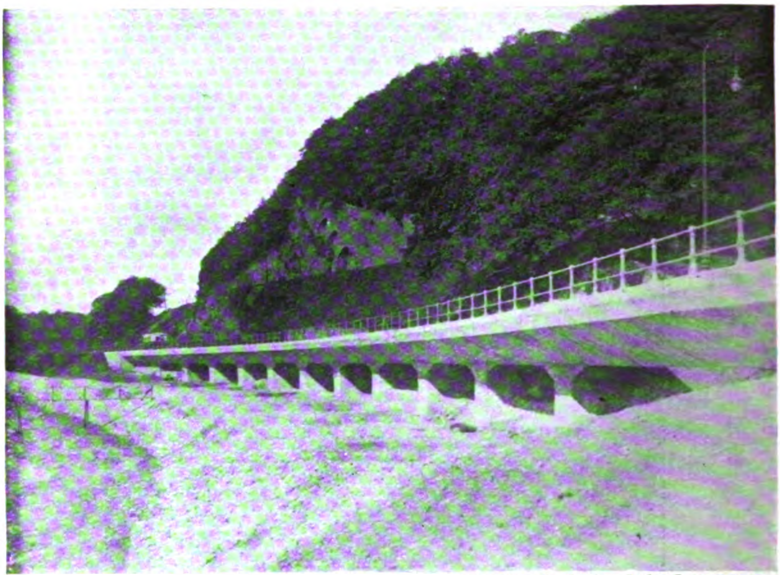
Precast Concrete, Ltd.

Some of the more important contracts executed by this firm during 1926 comprise:

Huddersfield Building Society reconstruction scheme, on which the firm was responsible for reinforced concrete construction, "Hollocast" floors, terrazzo staircase, walling and floors, mosaic work, composition flooring, marble walling, etc.—"Hollocon" concrete roofing slabs, for Messrs. Brunner, Mond & Co., Ltd., Northwich.—"Hollocast" floors were used on the following contracts: Deansgate Hotel (second extension), Manchester; J. J. Hadfield, Ltd., Chinley; Sandoz Chemical Co., Ltd., Bradford; new Nurses' Home, Oldham; reservoir cover, Grange-over-Sands; also on contracts at Hull, Hanley, Slaidburn, Stockport, Honley, Bacup, Chester, Matlock, Leeds, Colne, Wellingborough, etc.

Reinforced Concrete Construction Co.

In addition to the special coloured bridge work (illustrated and described elsewhere in this number), the contracts on which the firm have been engaged during 1926 include Coed Madoc Bridge, Nantlle Lake Bridge, Ty Coch Bridge, and an 800-ft. road retaining wall at Tyddyn Badyn, for Caernarvonshire County Council; Penns Lane Bridge, for the borough of Sutton Codfield; Beevor Bridge, for the Barnsley Corporation; Detton Ford Bridge, for the Cleobury



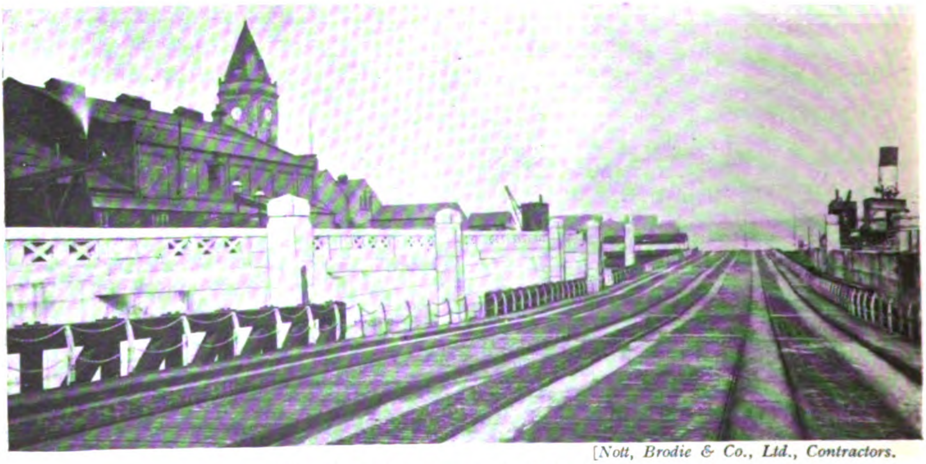
[Nott, Brodie & Co., Ltd., Contractors.

Bristol Portway: Viaduct between Cliff and River.

Mortimer R.D.C.; Crowhole Bridge, for the Chesterfield R.D.C.; a retaining wall for the Worcester City Council; grain silo at Manchester docks, for John Jackson & Sons, Ltd.; and a coal bunker, for the London Midland & Scottish Railway.

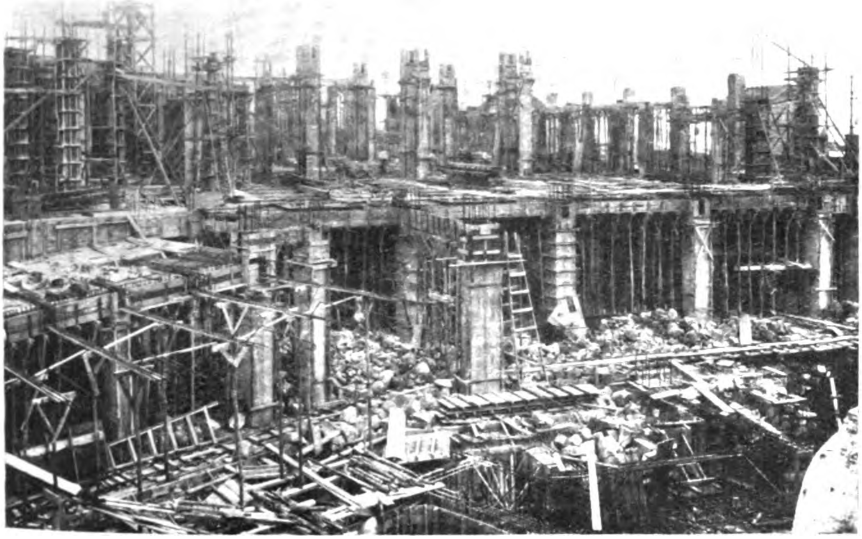
Saxild & Partners.

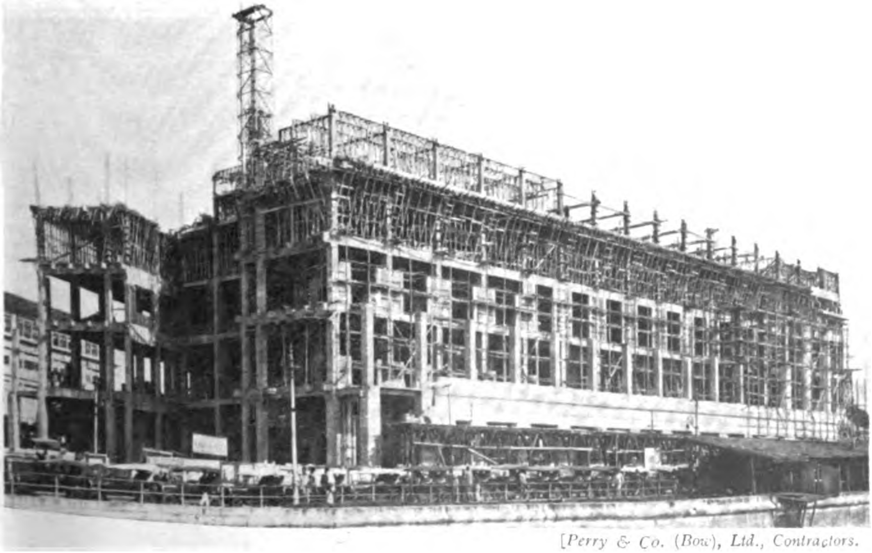
The principal work in which this firm is now interested is the large factory for the Michelin Tyre Co., at Stoke-on-Trent, in the design and erection of which they are collaborating with Messrs. Peter Lind & Co. Some particulars of this factory, which will cost about £350,000, are given on p. 93. Other works now in hand include a quay wall for the Southampton Corporation, and a sea wall for the Teignmouth Urban District Council.



[Nott, Brodie & Co., Ltd., Contractors.

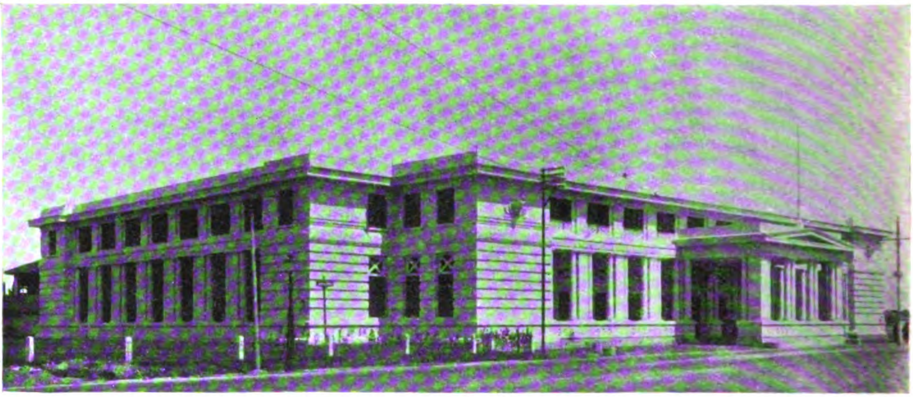
Floating Roadway at Seacombe.





[Perry & Co. (Bow), Ltd., Contractors.

New General Post Office, Singapore.



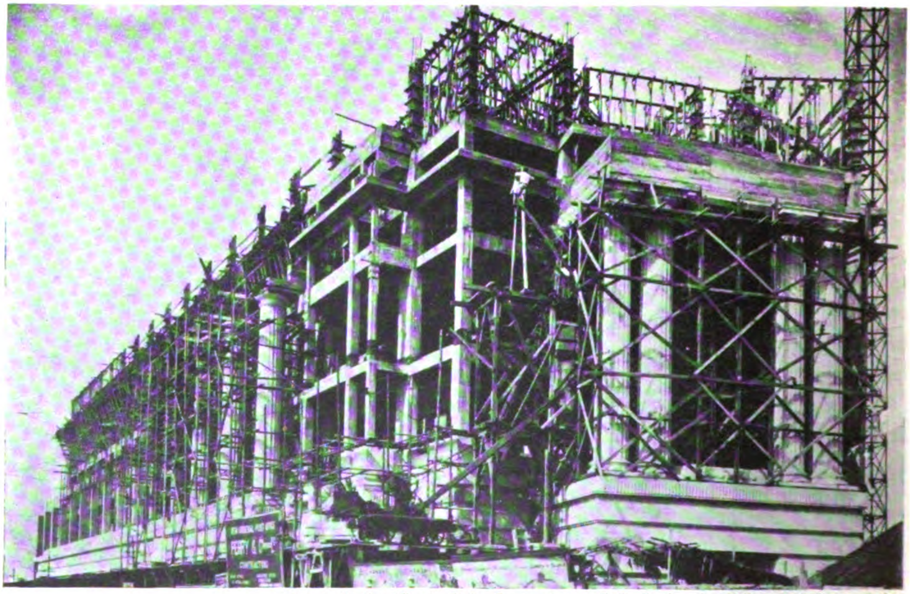
[*Perry & Co.* (*Bow*), *Ltd., Contractors.*

Sailors' Home, Singapore.

Simon-Carves, Ltd.

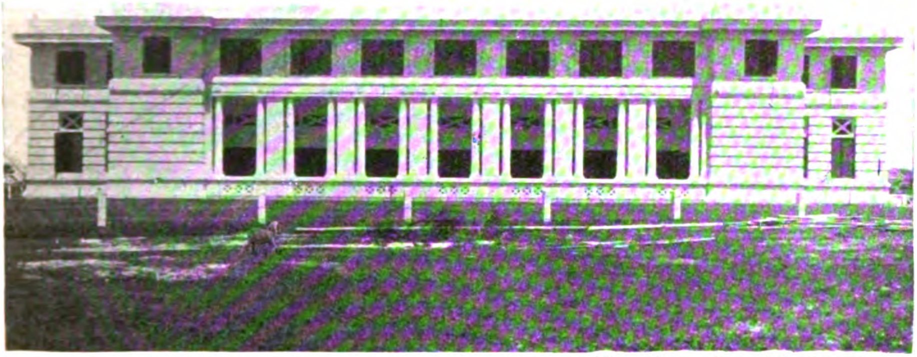
The following are amongst the principal reinforced concrete contracts carried out and in course of erection by Messrs. Simon-Carves, Ltd., of Manchester, during 1926:

Tar tanks (450,000 gallons capacity) at Coedeley, for the Welsh Navigation Steam Coal Co., Ltd.; Water tower (60,000 gallons) at Thoresby, for the Bolsover Colliery Co., Ltd.; Service bunker (300 tons capacity) for the Wharncliffe Woodmoor Colliery Co., Ltd.; Coal hopper (600 tons capacity) at Blidworth, for the Newstead Colliery Co., Ltd.; Ropeway bunker (50 tons capacity) at Llay Main, for Messrs. R. White & Sons, Ltd., of Widnes; Hypochlorite storage tanks (80,000 gallons capacity) at Llandarcy, for National Oil Refineries, Ltd.; Coal store (1,000 tons) at Warring-



[*Perry & Co.* (*Bow*), *Ltd., Contractors; R.C. Design by Edmond Coignet, Ltd*

New General Post Office, Singapore.



[Perry & Co. (Bow), Ltd., Contractors.

Sailors' Home, Singapore.

ton Gas Works, for Warrington Corporation; Settling ponds, of 83,000 gallons capacity, for Messrs. Richard Evans & Co., Ltd., of Lyme Pits, Lancs.

In addition to the above, the firm has carried out nine large washery contracts similar to that shown in the illustration, each comprising a complete washery building, with slurry tower having a capacity of from 75,000 to 200,000 gallons, and a feed hopper to receive coal from wagons and belt conveyors.

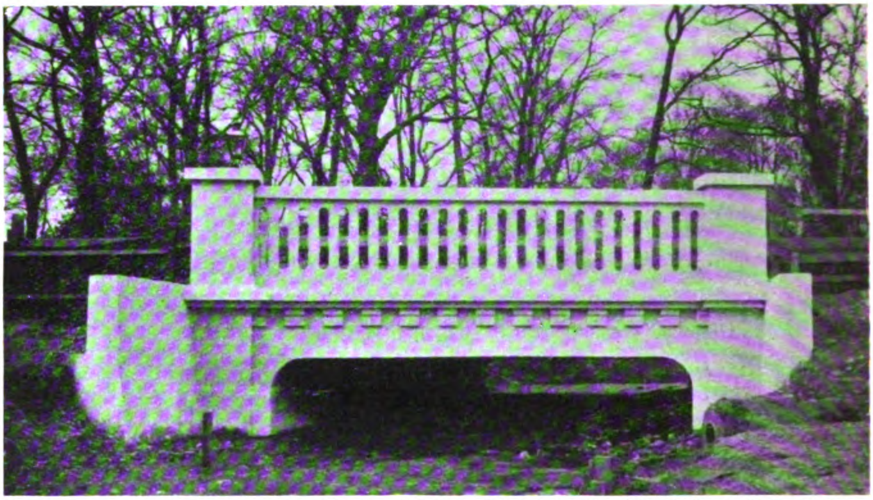
J. & W. Stewart.

Contracts completed or in course of completion during 1926 by this firm include the following:

Further work on excavation and foundation contracts for the new Parliament Buildings for the Government of Northern Ireland, at Stormont, near Belfast, together with an electricity sub-station at Stormont. The foundations for all the work in connection with the Parliament

[Reinforced Concrete Construction Co., R.C. Designers & Contractors.

Coed Madoc Bridge, Carnarvonshire.

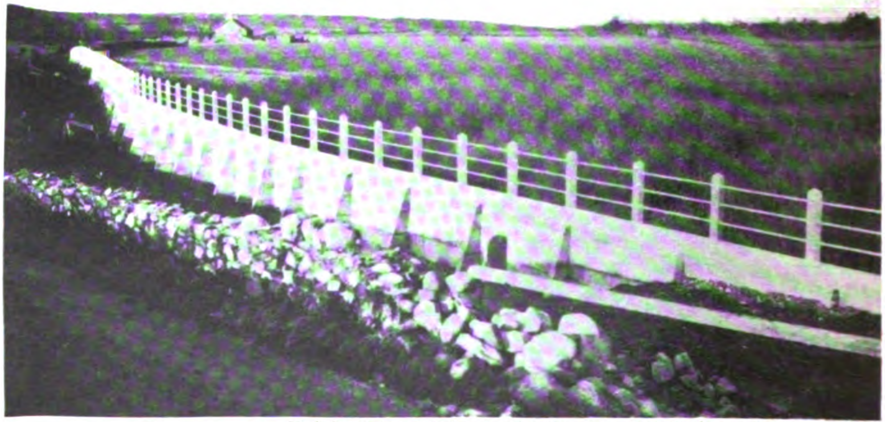


[*Reinforced Concrete Construction Co., R.C. Designers & Contractors.*

Penn's Lane Bridge, Sutton Coldfield.

Buildings are in reinforced concrete. This was divided into the following sections:—(1) Foundations to Parliament House; (2) foundations to heavy raft to carry tower; (3) foundations to main approach stairs; (4) retaining walls. In items (1) and (4) a mixture of 1 part Portland cement to 6 of broken stone and sand was used. The stone was graded from 2 in. down to $\frac{3}{16}$ in. In items (2) and (3) a mixture of 4 to 1 was used, the stone in this case being graded from $\frac{3}{4}$ in. down to $\frac{3}{16}$ in.

Nearly 20,000 cube yards of concrete were deposited in the whole of the foundations. This was done by means of five batch mixers. The gauging of the material was done in $\frac{1}{2}$-cube yard wagons, partitioned off to give the proper amount of stone and sand. The mixing was

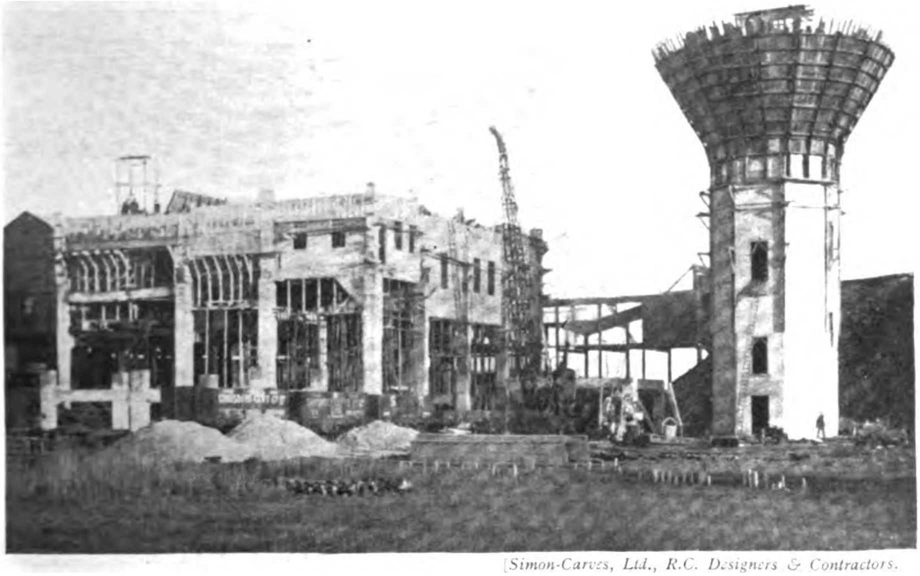


[*Reinforced Concrete Construction Co., Ltd., R.C. Designers & Contractors.*

Road Retaining Wall at Tyddyn Badyn, Carnarvonshire.

practically all done from one spot, and chutes were formed from each of the five mixers into ¾-cube yard wagons man-handled to the various positions on the work.

The raft for the tower is reinforced throughout with 1¼ in. bars. This heavy raft had to be done in four sections, the concrete in each section having to be inserted in one continuous operation. There were approximately 400 cube yards of concrete in each section, and this amount of concrete was mixed and placed in one day. Test cubes were periodically made of all the concrete ; in the 6 to 1 mixture the crushing load came to 253 tons per sq. ft., and in the 4 to 1 concrete the cubes remained unbroken at 400 tons per sq. ft.



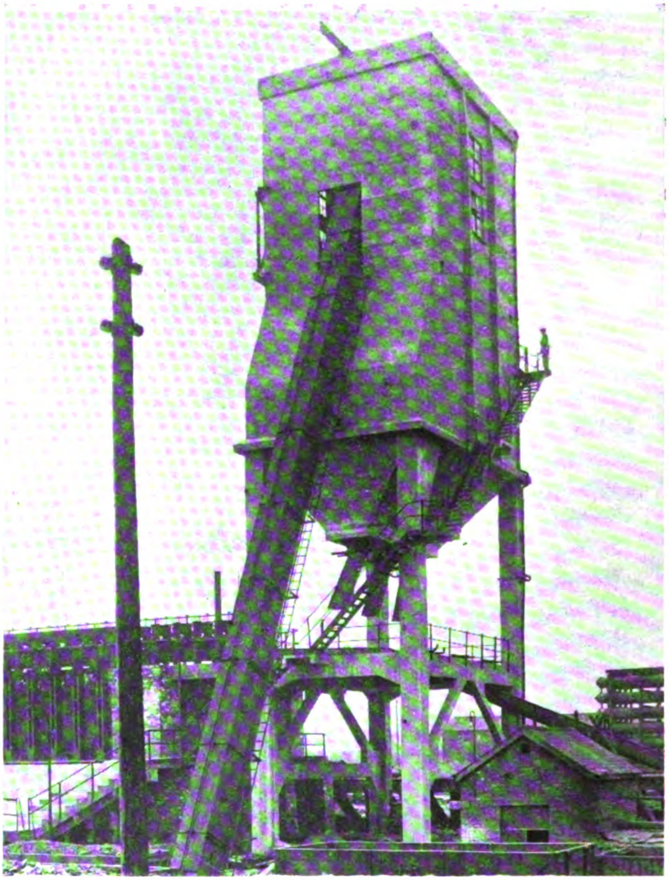
[Simon-Carves, Ltd., R.C. Designers & Contractors.

Washery and Slurry Tower at Haydock, Lancs.

The excavation for this work included the excavation and disposal of about 300,000 cube yards of earth, and spreading same to form embankments for future approach roads. This excavation was done by mechanical shovels, and the conveying of the material to the site of the approach roads was done by aerial monocable and gravity winches.

The complete drainage scheme was also carried out under this contract, and involved the laying and jointing of about two miles of cast-iron and concrete piping, about 1,000 lineal feet of which was done by tunnelling in order not to interfere with the surface work, such as excavation and concrete. In all cases the manholes for this drainage scheme are in pre-cast concrete shafts.

Foundations to new power station, Stourport, for the British Electrical Federation (Engineer, Mr. C. W. G. Little) : This contract, with many additions which more than doubled the original value, was completed in August, 1926. The foundations consist of a reinforced concrete raft carried on Raymond piles driven down to rock level. Inlet and outlet culverts for circulating water were constructed in reinforced concrete at depths of 20 ft. and 10 ft. respectively below ground level. The base of the inlet culvert was founded directly on rock, but for the outlet culvert it was necessary to construct dwarf walls below the base down to a firm foundation. The site is on the bank of the river



[*Simon-Carves, Ltd., R.C. Designers & Contractors.*

300-ton Coal Bunker.

Severn, and, there being much water in the ground, the deep excavations were protected by steel sheet piles. Steel sheet pile coffer-dams were driven in the Severn around the ends of both inlet and outlet culverts to enable four bell-mouth inlets and one bell-mouth outlet to be constructed. Two of the four inlets were provided to allow for future extension. For the purpose of diverting the river Stour, two steel coffer-dams were driven in the river that the connections to the new waterway might be made.

Reconstruction of Wiggenhall Bridge for the Watford Borough Council (Engineer, Mr. W. W. Newman): This bridge was constructed in reinforced concrete, and consists of two skew-spans over the river Colne carried on pre-cast reinforced concrete piles. Although it was generally expected that a satisfactory set would be obtained on piles about 20 ft. long, the solid stratum known to be at this depth was found to be too thin to be relied upon. The two 20-ft. test piles were lengthened *in situ* twice and re-driven; it was then decided to make all piles 40 ft. long. Even so the sets obtained were such as to make it necessary to increase considerably the number of piles required. The retaining walls on each side of the river, both under and at the sides of the bridge, were constructed with reinforced concrete sheet piles. The decking was carried on longitudinal beams, all of reinforced concrete.

Reconstruction of Manor Way Bridge, for the Port of London Authority

(Engineer, Mr. A. Binns): The original steel girder bridge over the railway at Manor Way Station was condemned some while ago, and a temporary timber bridge erected in the place of part of it, there being no room at either side. The usual heavy road traffic to and from both Woolwich and the Royal Albert Docks is to be maintained over the site of the new bridge without interruption throughout the reconstruction. At the same time, the railway traffic under the bridge is to be continued, including passenger service at Manor Way Station which is also at the site. The new bridge will consist of reinforced concrete decking carried by steel girders on heavy concrete abutments. The bases of the two abutments are connected underneath the rails by a reinforced concrete invert. Some of the new station buildings will, as before, be erected on the new bridge.

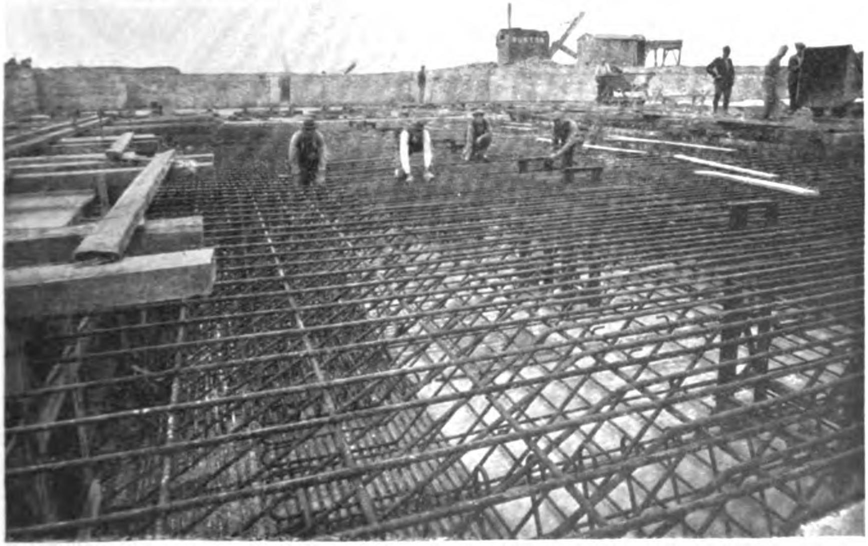
Stewart & Partners, Ltd.

Contracts completed or in course of completion during 1926, include:

Reconstruction of London-Yarmouth Road, Latinford Diversion, for the East Suffolk County Council (County Surveyor, Mr. A. Jervis): This contract was for a new by-pass road about three-fifths of a mile long through open country. The carriage-way, which is in the main cutting, consists of an 8-in. mass concrete slab; the remaining portion, in some places on virgin ground and in others on very shallow embankments, is a reinforced concrete slab, 7 in. thick. Bitumen expansion joints were provided across the road at an angle with the kerb. The contract has just been completed.

London-Yarmouth Road (Section A 12, Kesgrave, Ipswich), for the East Suffolk County Council (County Surveyor, Mr. A. Jervis): This contract consisted of widening about 3½ miles of existing road, the additional width required being formed with mass concrete.

Sonning and Twyford By-passes (Great Bath Road Improvement Scheme), for the Berkshire County Council (County Surveyor, Lt.-Col. Hawkins): The Sonning and Twyford By-passes are two separate stretches of new road approximately 1 mile and 2½ miles long respectively. It is intended to construct the 30-ft. carriage-way in reinforced concrete throughout, the aggregate for the lower 5 in. being graded stone and for the top 2 in. granite chippings. Bitumen expan-



J. & W. Stewart, Contractors.

Reinforcement for Raft, New Parliament Buildings, for Government of Northern Ireland, Belfast.

[J. W. Stewart, Contractors.

Wiggenhall Bridge, Watford.

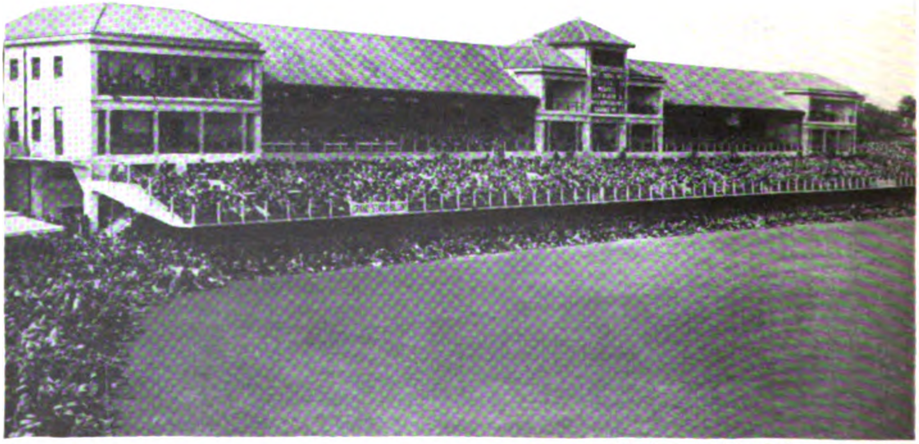
sion joints will be provided at intervals across the road at an angle with the kerb.

Trollope & Colls, Ltd.

In addition to the reinforced concrete constructional work carried out and supervised in many large contracts completed in 1926 by Messrs. Trollope & Colls, Ltd., the Engineering Department has completed the stands at Lord's Cricket Ground for the M.C.C. This contract presented many difficult features, one of which was that the whole of the work had to be completed between the two Cricket Seasons of 1925 and 1926, which entailed working under severe weather conditions throughout. The work consisted in constructing the main grand stand on the site of the old, and also an addition to the Mound stand.

Both stands are of an exceptionally interesting cantilever construction, specially designed to eliminate the presence of columns which might obstruct the view. This will be seen from the photograph, where the two 90-ft. lengths of covered seating at the back provide an uninterrupted view of play. The stands accommodate approximately 6,400 persons, exclusive of private boxes, and provide for bars, luncheon rooms, lavatories, etc. The illustration shows the stand fully occupied on the occasion of the trial match England v. The Rest on June 5, 1926. The architect is Sir Herbert Baker, A.R.A., F.R.I.B.A., and the engineer Dr. Oscar Faber, O.B.E., M.Inst.C.E.

Messrs. Trollope & Colls have also this year made a new departure by establishing at Worton Road, Isleworth, a yard for the manufacture of pre-cast concrete units, such as large pipes for sewage, kerbs, blocks, etc., which are being manufactured on the most up-to-date lines and with the aid of some novel and interesting machines.


[Trollope & Colls, Ltd., Contractors.

The Stand at Lord's Cricket Ground.

[R.C. Design by Trussed Concrete Steel Co., Ltd.

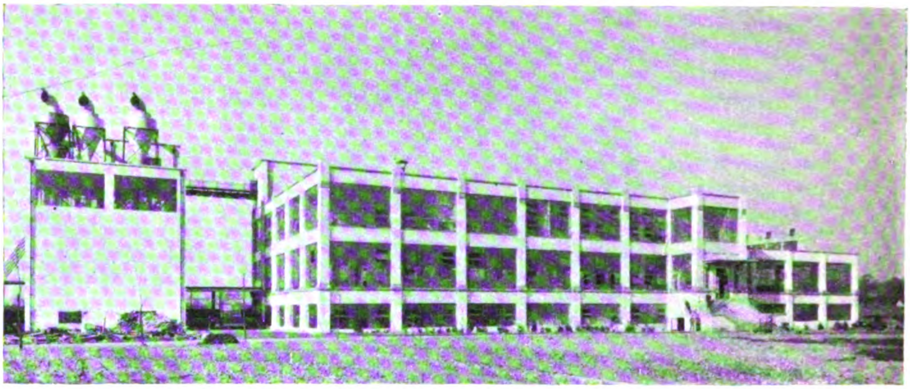
50,000-gallon Water Tower in Cheshire.

Trussed Concrete Steel Co., Ltd.

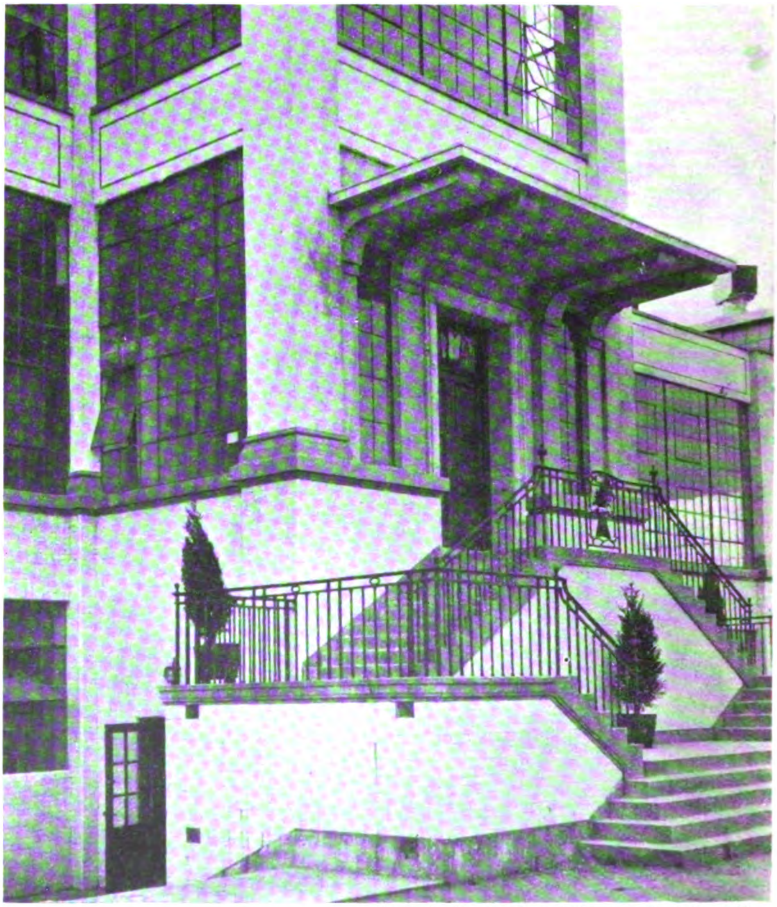
During 1926 a large number of industrial buildings were carried out on the Kahn system, including: Factories for Vauxhall Motors, Johnson Matthey & Co., Kodak, Ltd., Brown & Co., H. Glenister & Co., Edward Lloyd, Ltd., Shredded Wheat Co., Ltd., and Wrigleys, Ltd.

It is perhaps of interest to note that the factories of the Shredded Wheat Co., Ltd., and for Wrigleys, Ltd., were of mushroom slab construction. The advantages of this system over a beam and slab construction are the complete elimination of depending beams, resulting in a flat ceiling throughout the building with no obstruction to light or air; the absence of projections from columns in the external walls greatly facilitates the placing of fixtures beneath the windows; maximum glass area can be obtained, giving the maximum lighting and ventilation; it is more economical than other forms of construction because the concrete and steel are more equally stressed and therefore utilised to the best advantage. This system is most suited to modern methods of rapid construction, as the bays are all of standard size and the centering can be repeated in any part of the building.

Other reinforced concrete structures of various types on which the company engineers have been engaged include the



General View.

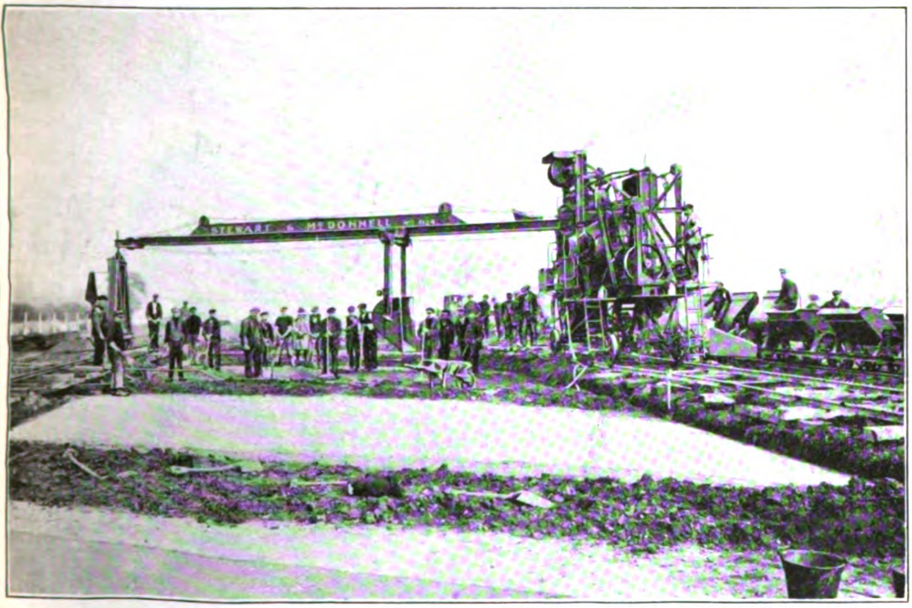


[R.C. Design by Trussed Concrete Steel Co., Ltd.

Shredded Wheat Factory, Welwyn Garden City: Main Entrance.

SPECIALISTS IN CONCRETE

ROAD CONSTRUCTION PLANT



Mixing and Boom Distributing Plant Working in Surrey.

MIXING AND BOOM DISTRIBUTING PLANTS.

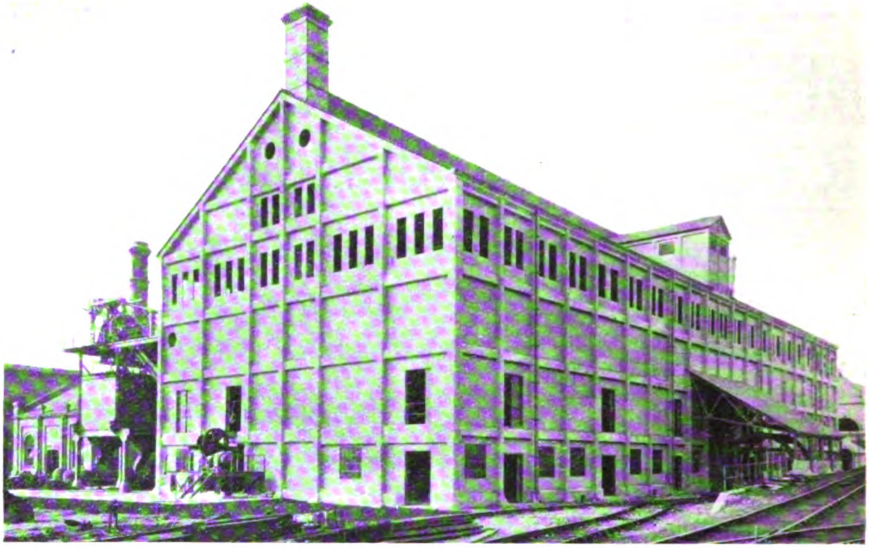
STANDARD CONCRETE MIXERS IN VARIOUS SIZES RANGING FROM 3 CUBIC FEET TO 2 CUBIC YARDS MIXED BATCH CAPACITY.

CONCRETE TIP CARTS, etc., etc.

STOTHERT & PITT LTD

MIXER DEPARTMENT.

BATH.



[*R.C. Design by Trussed Concrete Steel Co., Ltd.*

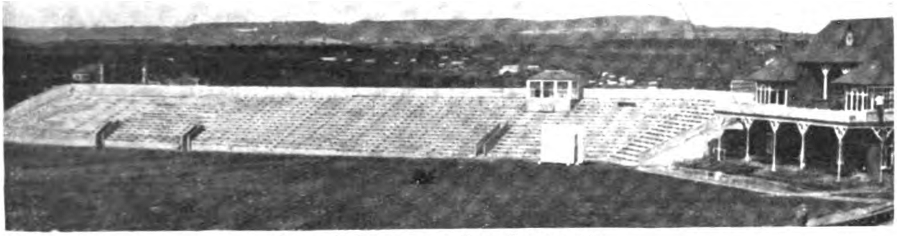
Gas Retort House at Waddon, Croydon.

following :—Scarborough Cricket Stand ; Redhill Football Pavilion ; Football Stand and Pavilion, Reigate ; Public Abattoir, Halifax ; Bridges at Wrexham, Twyford, Preston, Sudbury, Great Bath Road, Berks and Middlesex County Councils ; Water towers at Stanmore and Wittersham ; Drying kilns for the Gramophone Co. ; Film coating building for Kodak, Ltd. ; Retaining walls at Bradford, Birmingham, and Bridlington.

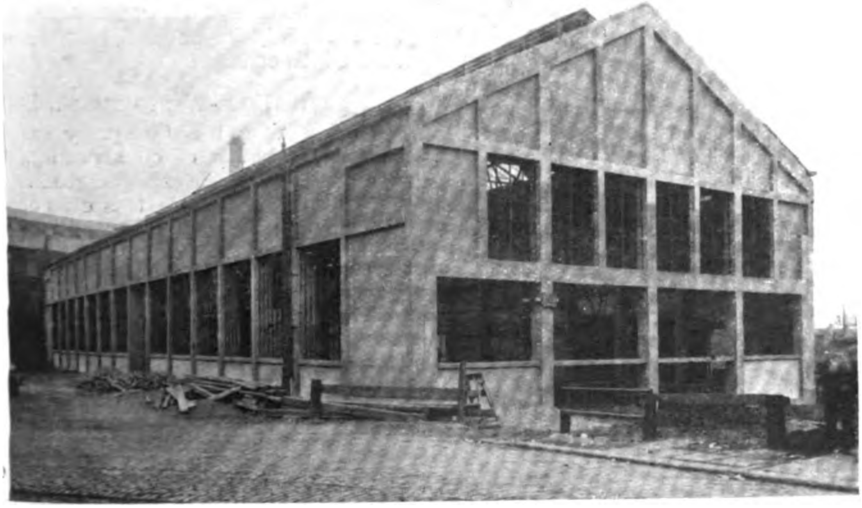
The " Truscon " floor has been laid in a large number of prominent buildings. The new Devonshire House in Piccadilly,

[*R.C. Design by Trussed Concrete Steel Co., Ltd.*

Shredded Wheat Factory, Welwyn Garden City.



Grand Stand at Scarborough.



Foundry at Huddersfield.

[R.C. Design by Trussed Concrete Steel Co., Ltd.

Factory at Bradford.

and Messrs. Cook's new head offices in Berkeley Street, have been completed; the new offices for Messrs. Holt, of Liverpool, calling for 50,000 square yards, are in course of construction; also the important block of offices for the Electricity Supply Co. at Newcastle.

Hospital contracts in which these floors have been used include: Lewisham General Hospital; Torbay Hospital, Torquay; Epsom Hospital; Beckett Hospital, Barnsley; Edward VII Hospital, Windsor; Royal Salop Infirmary, Shrewsbury; Glossop Infirmary; Royal Hospital for Sick Children, Glasgow.

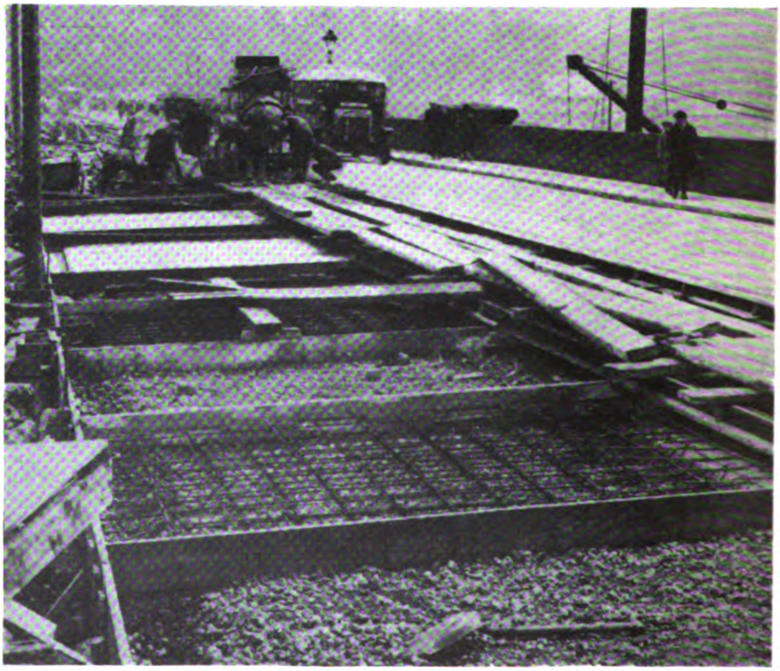
Schools include: Edward VI School, Birmingham; Secondary School, Wolstanton; Blackness Road School, Dundee; Secondary School, Ashton-under-Lyne; Grammar School, Hulme; and Boys' School, Bradford.

"Hy-Rib" combined reinforcement and centering, manufactured by this Company at their works at Trafford Park, Manchester, has been largely used. Two important buildings now being erected in London, each calling for a substantial yardage of "Hy-Rib," are the Royal Hotel, Woburn Place, for Imperial Hotels, Ltd., and the rebuilding scheme for Messrs. Bourne & Hollingsworth, Ltd., in Oxford Street. Extensions to the Kemsley Mills, Sittingbourne, for Messrs. Edward Lloyd, Ltd., called for 150,000 sq. ft. of this metal lathing.

The Company is also interested in a large number of works that are about to commence, including new factories on the Kahn system for Barker & Dobson, Liverpool; British Insulated & Helsby Cables, Ltd.; David Greig, Ltd.; important works for the Hull Corporation; reservoirs at Neston and Parkgate; and a considerable number of "Truscon" floor contracts.

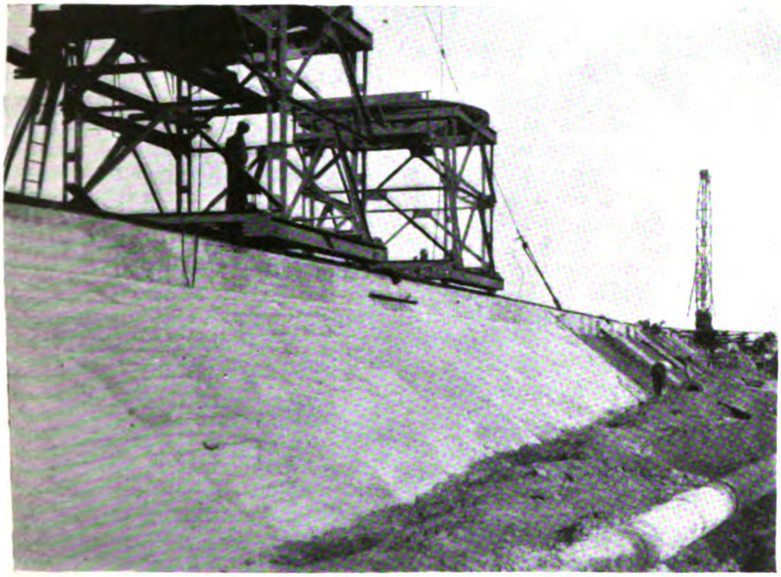
The Walker-Weston Co., Ltd.

During 1926 this Company has continued its policy of constructing, with guarantees, concrete surfaced roads. The Company specialises in this class of construction, carried out in accordance with their patented methods, comprising the alternate bay system, with interlocking



[*Walker-Weston Co., Ltd., R.C. Designers & Contractors.*

Concrete Road at Burton-on-Trent.



[Walker-Weston Co., Ltd., R.C. Designers & Contractors.

Reinforced Concrete Crane Track at Cantley.

expansion joints, large aggregate in the surface layer and with the section of the road and the reinforcement designed to meet special circumstances. Some of the roads have been constructed with central drainage, the section being inverted. The Company are general reinforced concrete contractors, and manufacturers of Pyramidal double-layer and single-layer reinforcements.

Among the various works carried out during the year are: Concrete surfaced main roads in the London Docks, St. Austell, Crediton, Bourne End, etc.; Factory roads in London and the provinces; Reinforced concrete quays, crane tracks, flumes, tanks, etc.; and the supply of reinforcement for roads generally.

Formwork.

When we published in this journal a few of the chapters from the treatise by Mr. A. E. Wynn, B.Sc., A.M.Am.Soc.C.E., on "The Design and Construction of Formwork for Concrete Structures," we had so many requests to publish them in book form that our readers will be glad to know that this has been done and that the volume is now ready. A small part of the work only appeared in this journal. In the book now published designs and notes on formwork for every type of concrete structure are given. An idea of the comprehensive nature of the work may be gained from the following list of chapters.

Chapter I.—Form Building in General.
Chapter II.—Materials, Loads, Pressures and Stresses.
Chapter III.—Theoretical Design of Forms.
Chapter IV.—Design Tables.
Chapter V.—Design Problems.
Chapter VI.—Detail Construction of Footing Forms.
Chapter VII.—Detail Construction of Column Forms.
Chapter VIII.—Wall Forms.
Chapter IX.—Detail Construction of Beam and Girder Floor Forms.
Chapter X.—Forms for Rib Floors and Structural Steel Fireproofing.
Chapter XI.—Miscellaneous Forms in Building Construction.
Chapter XII.—Forms for Flat Slab Construction.
Chapter XIII. — Forms for Conduits, Sewers and Culverts.
Chapter XIV—Forms for Tanks, Silos, Bins and Standpipes.
Chapter XV.—Forms for Dams, Piers and Heavy Walls.
Chapter XVI.—Steel Forms in Building and Wall Construction.
Chapter XVII.—Steel Forms for Curved Surfaces.
Chapter XVIII.—Arch Falsework.
Chapter XIX.—Other Bridge Forms.
Chapter XX.—Patent Devices.
Chapter XXI.—Planning the Work.

Wood shuttering for every purpose in building construction and engineering works is dealt with, and in each case are given clear drawings showing the best method of construction, details of costs, quantities of materials required, and full explanatory notes on preparing and erecting the formwork. Steel forms are fully dealt with in two chapters, while the many devices which are common practice in the United States but practically unheard of in this country are described and illustrated.

A special feature of the volume are the design tables, from which the most economic selection of materials for different purposes may be seen at a glance. These tables, which are presented in a large and clear style as folders, include:

1. Maximum span of floor sheathing for various thicknesses of slab.
2. Maximum span of wall sheathing for various heights of wall.
3. Maximum span of column sheathing for various heights of column.
4. Maximum spacing of floor joists for various spans and thicknesses of slab.
5. Maximum concentrated loads carried by ledgers and wales for various spans and spacing of loads.
6–9. Spacing of column yokes for various sizes and heights of column.
10. Maximum spacing of wales and wall ties of various sizes of studs and heights of wall.
11. Safe loads on posts.

There are no less than 219 illustrations (diagrams and photographs) covering formwork for every type of structure, all reproduced on a large scale.

This is the only book in the English language dealing exhaustively with shuttering for concrete structures. The author, who is a practical designer and contractor, has had a very wide experience in all classes of construction both in this country and America, and has made a special study of the subject of formwork. The results of his experience are given in this volume in simple language, so that advantage can be taken of it by all concerned with the erection of concrete structures.

The book is strongly bound in cloth, and comprises 320 pp. It is obtainable from Concrete Publications, Ltd., 20 Dartmouth Street, Westminster, S.W.1. Price 20*s*. (postage 9*d*. extra).

DATA FOR PRICING REINFORCED CONCRETE.*

MATERIALS DELIVERED 4 MILES FROM CHARING CROSS.

		s.	d.
Best Washed Sand	per yard	16	0
Clean Shingle, ¾ in. mesh	,,	14	0
,, ,, ½ in. mesh	,,	15	6
Thames ballast	,,	10	6
Broken brick (¾ in.)	,,	11	6
Best British Portland Cement	per ton	58s. to 63	6
"Ferrocrete" Rapid-Hardening Portland Cement	delivered London 10s. per ton extra		
"Super-Cement"	per ton	88s. to 93	0
"Lightning" Brand Aluminous Cement	,,	100s. to 105	6
Ciment Fondu	works f.o.r.	95	0

Boarding for Shuttering—

		Sawn. s.	Sawn. d.	Wrot. s.	Wrot. d.
1 in.	per square	23	6	27	6
1¼ in.	,,	29	6	33	6
1½ in.	,,	35	6	41	0

Sawn Timber for Struts and Supports—

3 in. by 4 in.	from £22 per standard
3 in. by 6 in. and 3 in. by 7 in.	,, £20 ,, ,,

Mild Steel Rods for Reinforcement—

		s.	d.
⅝ in. to 2½ in. Rounds	per cwt.	10	6
7/16 in. to ½ in. Rounds	,,	10	9
⅜ in. Rounds	,,	11	0
¼ in. Rounds	,,	12	0

Breeze Slabs per yd. super: 2 in., 1/11; 2½ in., 2/4; 3 in., 2/9; 4 in., 3/6.

MATERIAL AND LABOUR, INCLUDING 10 PER CENT. PROFIT.

(Based on Contracts up to £2,000.)

Portland Cement Concrete well mixed in proportion 1 : 2 : 4—

				s.	d.
Do	do.	in foundation	per foot cube	1	11
Do.	do.	in columns	,, ,,	2	1
Do.	do.	in beams.	,, ,,	2	3
Do.	do.	in floor slabs 4 in. thick	per yard super	6	0
Do.	do.	in floor slabs 5 in. thick	,, ,,	7	6
Do	do.	in floor slabs 6 in. thick	,, ,,	9	0
Do	do.	in floor slabs 7 in. thick	,, ,,	10	6
Do	do.	in walls 6 in. thick	,, ,,	8	8

(Add for hoisting 3s. 6d. per yard cube above ground-floor level. Add for "Ferrocrete" 1s. 10d. per yard cube.)

Steel Reinforcement, including Cutting, Bending and putting into Position and securing with Stout Binding Wire—

		s.	d.
From ¼ in. to ⅜ in.	per cwt.	22	6
,, 7/16 in. to ½ in.	,,	21	6
,, ⅝ in. to 2½ in.	,,	20	6

EXTRA LABOUR TO BENDS in ¼-in. rods, ½d.; ⅜-in. rods, 1d.; ½-in. rods, 1¼d.; ⅝-in. rods, 1½d.; ¾-in. rods, 1¾d.; ⅞-in. rods, 2d.; 1-in. rods, 2¼d.; 1⅛-in. rods, 3d.; 1¼-in. rods, 3½d. (per bend per cwt.).

EXTRA LABOUR TO HOOK BENDS: ¼ in., 1d.; ⅜ in., 2d.; ½ in., 2½d.; ⅝ in., 3d.; ¾ in., 3½d.; ⅞ in., 4d.; 1 in., 4½d.; 1⅛ in., 6d.; 1¼ in., 7d. (per bend per cwt.).

Shuttering—

		s.	d.
Shuttering and Supports for Concrete Walls (both sides measured)	per square	59	0
Centering to Soffits of Reinforced Concrete Floors and Strutting, average 10 ft. high	per square	55	0
Do. do. in small quantities	per ft. super	0	10
Shuttering and Supports to Stanchions for easy removal, average 18 in. by 18 in.	per ft. super	0	11½
Do. do. as last, in narrow widths	,, ,,	1	1½
Do. do. to sides and soffits of beams, average 9 in. by 12 in.	,, ,,	1	1½
Do. do. as last, in narrow widths	,, ,,	1	3½
Raking, cutting, and waste to shuttering	per ft. run	0	3
Labour, splay on ditto	,, ,,	0	2
Small angle fillets fixed to internal angles of shuttering to form chamfer	,, ,,	0	3

WAGES.—The rates of wages on which the above prices are based are:—Carpenters and joiners, 1/9½ per hour; Carpenters working on old shuttering, 1/10½; Labourers on building works, 1/4½; Men on mixers and hoists, 1/5½; Bar-benders, 1/5½.

[* This Data is specially compiled for *Concrete and Constructional Engineering*, and is strictly copyright.]

Prospective New Concrete Work.

ABERCARN.—*Houses.*—The U.D.C. proposes to build 60 houses.

BACUP.—*Houses.*—The Council proposes to build 76 houses on the Blackburn estate.

BARNSLEY.—*Reservoir.*—The Corporation has made application for Parliamentary powers to construct a reservoir at Royal Moor. The cost is estimated at £362,000.

BEXHILL-ON-SEA.—*Concrete Pavilion.*—The Poole Town Council proposes to spend £10,000 on the construction of a reinforced concrete pavilion, consisting of 42 bungalows and 148 bathing cubicles.

BO'NESS.—*Houses.*—The T.C. proposes to erect 200 houses in Deanfield Road.

BRADFORD.—*Houses.*—The Corporation proposes to build 882 houses on the estate at Ecckeshill.

BRIERLEY.—*Houses.*—The P.C. has approached the District Council for permission to erect 100 houses.

BURNTISLAND.—*Houses.*—The Housing Committee recommends the T.C. to erect 40 houses at Haugh.

COWES, I.O.W.—*Quay.*—The Southern Railway Co. is considering a proposal to provide a new quay at Cowes.

CROMPTON.—*Houses.*—The U.D.C. proposes to build 80 houses.

CUMBERLAND.—*Concrete Bridge.*—The old Eamont Bridge, which connects Cumberland and Westmorland at Penrith, is to be replaced by a reinforced concrete structure. The cost of the new bridge is estimated at £40,000.

DAWLISH.—*Houses.*—The U.D.C. is seeking permission from the M.H. to erect 60 houses on a site at Oak Hill. The cost is estimated at £32,941.

DOVER.—*Concrete Bridge.*—A reinforced concrete bridge is to be constructed at Common Lane, Dover.

DUKINFIELD.—*Houses.*—The T.C. proposes to build 178 houses in Clarendon Fields.

DUNDEE.—*Promenade.*—The Corporation Works Committee proposes to extend the Dundee Esplanade.

EDINBURGH.—*Bridge.*—The Streets and Buildings Committee is considering a proposal to erect a bridge to connect Bothwell Street and Albion Terrace.

EDMONTON.—*Houses.*—The U.D.C. has applied for sanction to build 180 houses.

ELLESMERE PORT. — *Houses.* — The U.D.C. is seeking permission to borrow £36,479 for housing purposes.

EXETER.—*Concrete Houses.*—The City Council have applied for permission to erect 108 concrete houses.

FELTHAM.—*Houses.*—The U.D.C. is considering a scheme for the erection of 200 houses.

FINNIESTON.—*Bridge.*—The Glasgow Corporation is seeking Parliamentary powers to build a bridge over the Clyde at Finnieston.

GOSFORTH.—*Houses.*—The U.D.C. has made application for sanction to borrow £20,500 for building 38 houses at Benton Square.

GOSPORT.—*Wharf.*—The T.C. has applied for sanction to borrow £15,000 for the reconstruction of Gosport wharf.

GREAT YARMOUTH.—*Sea Wall.*—The T.C. has applied for sanction to borrow £8,411 for the construction of a sea wall and outer promenade from Sandown Road to Beaconsfield Road.

HAWICK.—*Houses.*—The T.C. has decided to erect 50 houses at Shorterdykes.

HETTON.—*Bungalows.*—The U.D.C. has applied for sanction to borrow £18,438 for the erection of 50 bungalows.

HEYWOOD.—*Houses.*—The T.C. has applied for sanction to borrow £51,730 for building 100 houses on a site at Darley Hall.

HOVE.—*Houses.*—The T.C. proposes to spend £49,000 on the erection of 100 houses on the Knoll estate.

HYDE.—*Houses.*—The T.C. is seeking permission to borrow £28,700 for the construction of 64 houses in Bennett Street.

LEICESTER.—*Houses.*—The Corporation Housing Committee recommends the purchase of the Westcote estate for housing purposes. The cost is £42,500.

LEVEN.—*Houses.*—The T.C. has been recommended to build 64 houses.

LONDON.— *Concrete Houses.*— The L.C.C. proposes to erect 100 concrete houses on the Downham housing estate.

LONGBENTON.—*Houses.*—The U.D.C. is seeking permission to borrow £20,500 for the erection of 38 houses.

MANSFIELD WOODHOUSE.—*Houses.*—The U.D.C. has applied for permission to borrow £18,150 for the erection of 38 houses in Slant Lane.

Mill Hill, Middlesex.—*Bridge.*—The County Council proposes to construct a bridge to carry a roadway 70 ft. in width at Selvage Lane.

Newcastle-on-Tyne.—*Houses.*—The Housing Committee has recommended the Council to apply for permission to build 1,160 houses.

Newry.—*Houses.*—The R.D.C. proposes to spend £40,260 on the erection of 108 cottages.

Norwich.—*Road.*—The T.C. is considering a scheme for the construction of a road from Jessop Road to Portersfield Road.

Penryn.—*Concrete Road.*—The T.C. proposes to spend £3,176 on the construction of a concrete thoroughfare in Commercial Road.

Pontefract.—*Concrete Water Tower.*—The Corporation proposes to spend £2,200 on the construction of a reinforced concrete water tower.

Portobello.—*Pier, etc.*—The Edinburgh Corporation is considering a proposal to construct a pier and an open-air swimming pool on the foreshore at Portobello. The cost is estimated at £100,000.

Pudsey.—*Houses.*—The T.C. is seeking sanction to build 300 houses.

Rotherham.—*Houses.*—The R.D.C. has applied for sanction to borrow £22,296 for building 51 houses at Brampton Bierlow.

Shrewsbury.—*Concrete Bridge.*—A 500-ft. reinforced concrete bridge is to be erected across the river Severn at Atcham.

Swanage.—*Groynes.*—The T.C. is considering a proposal to construct groynes on the beach.

Tottenham (London).—*Concrete Houses.*—The L.C.C proposes to erect 282 concrete houses on the White Hart Lane estate.

Wakefield.—*Concrete Houses.*—The Housing Committee proposes to build 300 concrete houses during 1927.

Winchester.—*Houses.*—The Corporation Housing Committee recommends the Council to build 100 houses.

Wisbech.—*Houses.*—The T.C. proposes to build 40 houses.

York.—*Houses.*—The T.C. is considering a scheme to erect 100 houses at Tang Hall.

Reinforced Concrete and Masonry Structures

Editors-in-Chief: GEORGE A. HOOL and W. S. KINNE.

Professors of Structural Engineering, University of Wisconsin. Assisted by a staft of fourteen specialists.

722 pages, 6 × 9, illustrated. Price 30*s*.

This book offers a practical and detailed discussion of every important element entering into the design and construction of concrete and masonry structures.

Particularly noteworthy are the very thorough treatments of Reinforced Concrete Buildings, Concrete Forms, Chimneys and Concrete Detailing. The complete progress report of the new Joint Committee on Concrete and Reinforced Concrete is included in the Appendix.

Much of the material appears in book form for the first time.

SECTION HEADINGS.—I.—Preparation and Placing of Concrete. II.—Forms for Concrete. III.—Bending and Placing Concrete Reinforcement. IV.—Finishing Concrete Surfaces and Waterproofing. V.—Reinforced Concrete Buildings. VI.—Retaining Wall Design. VII.—Slab and Girder Bridges. VIII.—Arches. IX.—Hydraulic Structures. X.—Chimneys. XI.—Concrete Detailing. XII.—Estimating Concrete Costs.

⁂ **Write for Catalogue No. 5, free on request.**

McGRAW-HILL PUBLISHING CO., LTD.

6 BOUVERIE ST. - - - LONDON, E.C.4.

Tenders Accepted.

Blisworth.—*Sewage Disposal Works.*—The Towcester R.D.C. has accepted the tender of Messrs. W. Smart & Son, Denton, Northants., at £3,171, for the construction of sewage disposal works at Blisworth. Other tenders submitted were: Bosworth and Wakeford, £3,658; G. B. Heap, £4,126; H. Middleton, £5,205; P. Trentham, Ltd., £3,992; R. Marriott, £3,250; A. Graham, Sons & Co., £5,719.

Burnley.—*Concrete Water Tower.*—The Corporation has accepted the tender of Messrs. Bolton & Hayes, Ltd., for the construction of a 20,000-gallon reinforced concrete water tower.

Burnley.—*Foundations.*—The T.C. has accepted the tender of Messrs. Christiani & Nielsen, at £850, for reinforced concrete foundation work.

Edinburgh.—*Foundations.*—The T.C. has accepted the tender of Messrs. J. Angus & Sons, Edinburgh, at £7,900, for the construction of reinforced concrete foundations at the electric generating station.

Hull.—*Concrete Water Tower.*—The Corporation has accepted the tender of Messrs. Whitaker & Co., Leeds, at £5,983, for the construction of a reinforced concrete water tower.

Hull.—*Concrete Sewer.*—The Corporation has accepted the tender of Mr. G. Curtis, Melrose Street, Hull, at £4,824, for the construction of a concrete sewer between Marfleet Avenue and Marfleet Lane.

Ilfracombe.—*Concrete Piling.*—The U.D.C. has accepted the tender of Messrs. J. Perkins & Sons, Ltd., Stokes Croft, Bristol, at £1,096, for the construction of reinforced concrete piling and decking in connection with the Council's pier. Other tenders submitted were: R. F. Yeo & Sons, £2,720; S. & J. Smethurst, Ltd., £1,225; P. Wilson & Co., £1,185; Simplex Concrete Piles, Ltd., £1,377.

DUCKHAM'S
CONCRETE
MOULD
OIL

GOES FARTHEST
FUNCTIONS BEST

ALEXANDER DUCKHAM & Co., Ltd.
6 BROAD ST. PLACE, LONDON, E.C.2

Liverpool.—*Concrete Slabs.*—The Corporation has accepted the tender of the Liverpool Artificial Stone Co., Ltd., for the supply of 20,000 superficial yards of concrete slabs, 2½ in. thick, at 5*s.* 3*d.* per superficial yard.

Taunton.—*Concrete Houses.*—The T.C. has accepted the tender of Messrs. F. & E. Small, Taunton, at £36,770, for the erection of 100 concrete houses. Other tenders submitted were: T. H. Moggridge, £39,475; G. Pollard & Co., £38,893.

Yarmouth, I.O.W.—The Council has accepted the tender of Mr. W. Downer, Totland Bay, at £2,065, for reinforced concrete piling work and raft in connection with the construction of new buildings at the entrance of the pier. Other tenders submitted were: Simplex Concrete Piling Co., Ltd., £3,329; J. Croad, £2,650; H. Moger, £2,068 17*s.* 6*d.*; Twymanns, £2,605 14*s.* 10*d.*

Trade Notices.

The "Curry Tyer."—In our last number we published an inquiry for the English agents for the "Curry Tyer." Messrs. Christmas & Walters, Ltd., of Caxton House, Westminster, S.W.1, inform us that they handle these ties.

Factory Floor Surfaces.—The Aberthaw Company, of 80 Federal Street, Boston, Massachussetts, U.S.A., inform us that they will be pleased to send free to readers of this journal copies of their publication, "Factory Floor Surfaces," noticed in our number for November last, and the price of which was therein stated to be one dollar.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XXII. No. 2. LONDON, FEBRUARY, 1927.

EDITORIAL NOTE.

Rapid Concrete Construction.

It is not surprising that during the past year the consumption of rapid-hardening Portland cement was more than double that of the preceding year, for the advantages of this material are such that it could not fail to receive immediate recognition. With this type of cement the period required for concrete to attain nearly its ultimate strength is reduced from 28 days to 4 days, and when to this saving in time, often a vital factor in itself, are added the further economies in labour and shuttering, the reason for the extensive replacement of ordinary Portland cement by rapid-hardening Portland cement is obvious. The saving in formwork costs is a very real one, and the fact that with rapid-hardening Portland cement concrete shuttering can be stripped and re-used in three or four days has been taken advantage of by many contractors; on the factory recently completed for Messrs. Wrigley's at Wembley the contractors (Messrs. A. Roberts & Co., Ltd.) designed a special system of shuttering consisting of steel forms and easily assembled constructional steel in place of the usual wood propping, with the object of taking the fullest advantage of the rapid-hardening properties of the cement used for the work. The method was entirely successful, and, we understand, considerably reduced the formwork costs.

The early tests on rapid-hardening Portland cement which showed that it resulted in considerably stronger concrete than the ordinary Portland cement have been amply proved by practical experience. Test cubes taken from actual construction work show that at 28 days a 1 : 3 : 6 mix of the best brands of rapid-hardening cement is as strong as a 1 : 2 : 4 mix of ordinary cement. An actual saving in cement is thus possible while obtaining concrete of the same strength, which if taken advantage of will offset the extra cost of the stronger material. Further, with the stronger concrete resulting from rapid-hardening Portland cement, stresses can be increased by about 20 per cent., with the consequent reduction in the size of reinforced concrete members and a saving in aggregate.

It has been proved that rapid-hardening Portland cement is, like aluminous cement, more immune from attack by frost than ordinary cement, due to the extra heat generated during setting. An interesting example of this comparative immunity from frost occurred during the construction of the new Bevans Works at Northfleet, described in our last number. A floor slab, 2 ft. thick, was poured immediately before a spell of frost last winter. The frost lasted for ten days, and it was noticed that during the whole of this period, although the ground was frozen hard all around, there was no sign of freezing on the slab; indeed, a shallow pool of water remained on it the whole of the time without freezing. On this work, test cubes made from concrete taken from ordinary batches gave a strength of 4000 lbs. per square inch at 7 days and 5000 lbs. per square inch at 28 days.

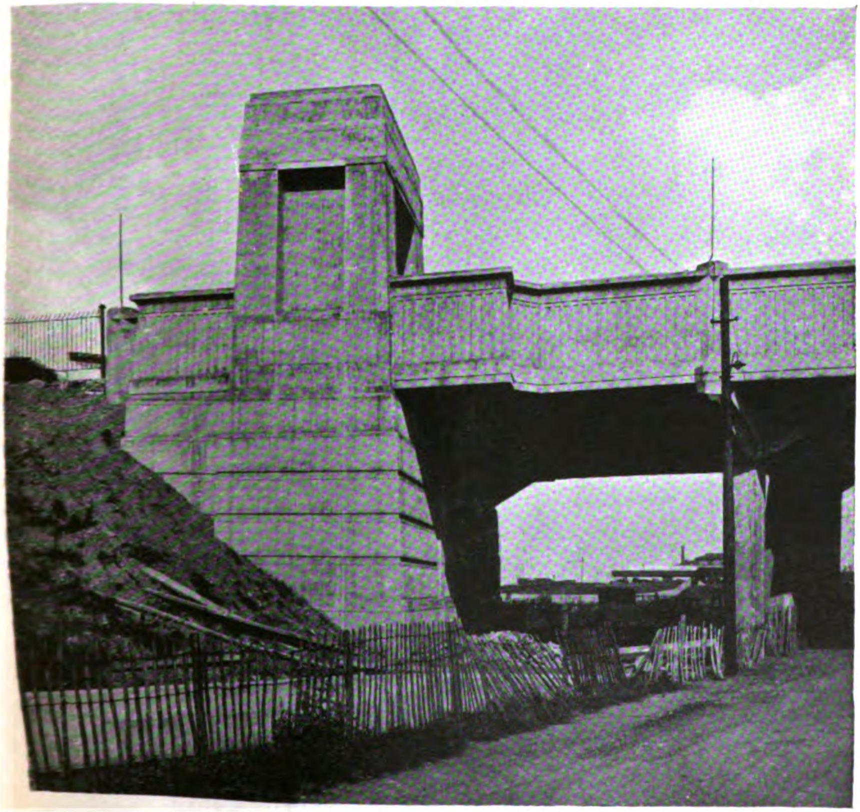
The manufacturer of pre-cast concrete is also making extensive use of rapid-hardening Portland cement which permits him to release moulds in 24 hours and to reduce the curing space considerably, and here again the saving in moulds and labour during curing is found to offset the extra cost compared with ordinary Portland cement.

We point out these facts in the interest of cement users generally. Rapid-hardening Portland cement is now far past the experimental stage; it is being used in ever-increasing quantities for a wide variety of purposes; it has entirely dispelled the idea that concrete construction takes longer than other materials. Rapid-hardening Portland cement has completely altered concrete practice of a few years ago, both as to time of construction and concrete strengths, and ultimately it will probably result in reducing costs in spite of its present slightly higher price. It is, indeed, more than probable that the time is not far distant when rapid-hardening cement will be the usual material for all kinds of concrete work, and ordinary Portland cement the exception.

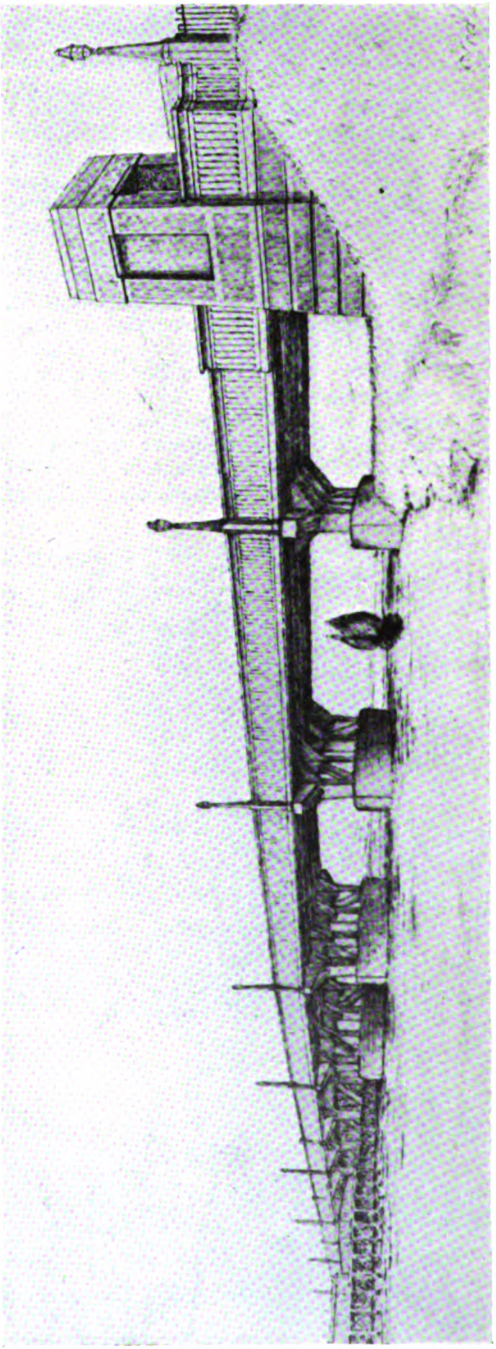
Reinforced Concrete Viaduct and Bridge at Barking.

THE completion of the bridge and viaduct on the new East Ham and Barking By-Pass Road, which has been constructed to relieve the congestion through East Ham and Barking, and also to facilitate traffic to and from Tilbury Docks and open up the foreshore on the north bank of the Thames in this district, marks another stage in the arterial road programme of the Ministry of Transport. It also forms another landmark in the architectural treatment of reinforced concrete, and an excellent example of the increasing tendency for architect and engineer to work in close collaboration in important engineering works. In this case Mr. Maxwell Ayrton, F.R.I.B.A., was appointed by the Ministry of Transport to act with Messrs. Mouchel & Partners, Ltd., the reinforced concrete executive engineers, with what result may be seen from the photographs we give of the completed structure.

This work is being carried out by the Ministry of Transport on behalf of the Essex County Council under the provisions of the Essex County Council (Barking Bridge) Act, 1923. The work is under the general direction of Mr. A. J. Lyddon, M.Inst.C.E., Chief Engineer of the Arterial Roads Department of the Ministry of Transport, and is placed immediately under the control of Messrs. L. G. Mouchel & Partners, Ltd., who were appointed by the Ministry to act as executive engineers for the work. The contractors are Messrs. Walter Jones & Sons, Ltd., of Westminster.

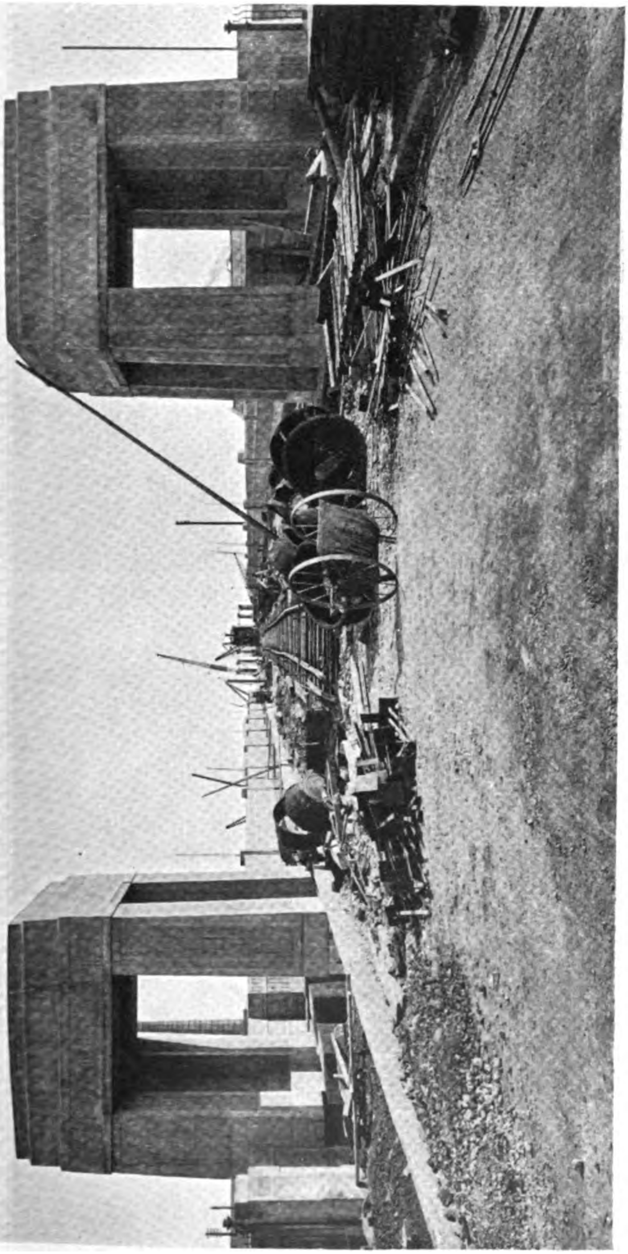


West Abutment.

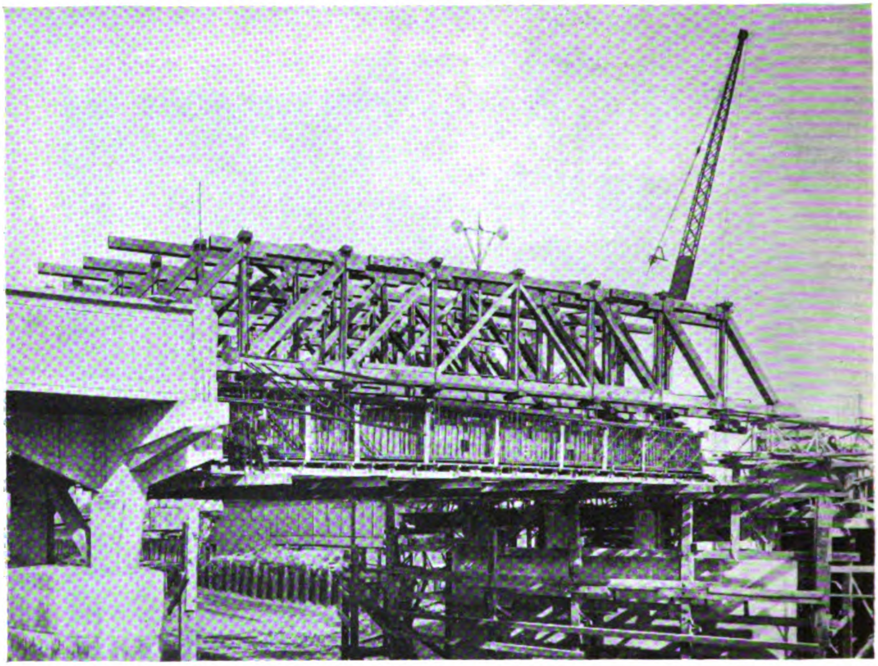


Mr. Maxwell Ayrton, F.R.I., B.A. Architect.

Reinforced Concrete Viaduct and Bridge at Barking.



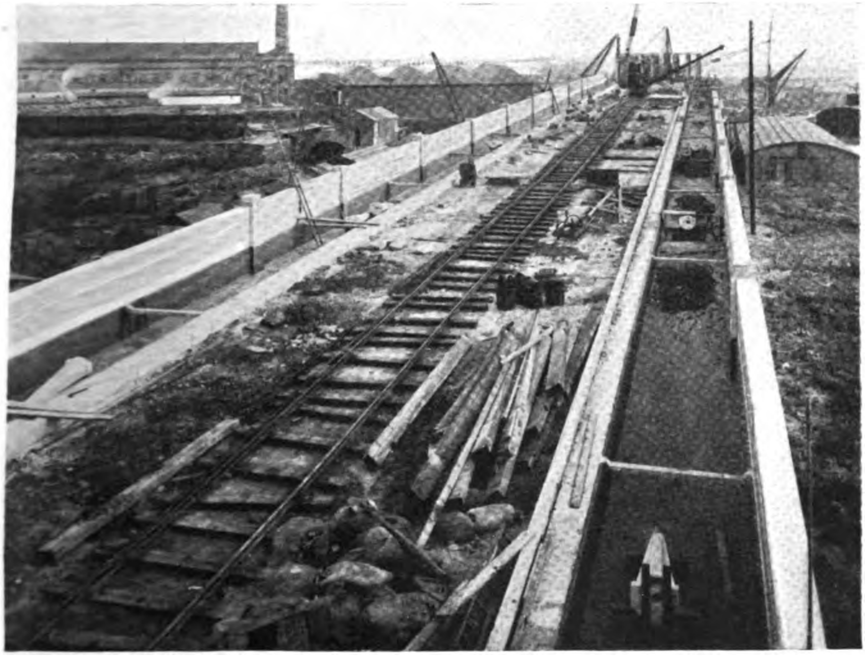
Pylons at West End.



Side View.

End View.

Temporary Trusses to Support Shuttering for Centre Span of 80 ft.



Viaduct Approach: Showing Ducts under Pavement to Carry Mains.

The works include a bridge over the river Roding, or Barking Creek, together with an approach viaduct terminating at the west end in a bridge over Jenkins Lane. The contract for the work was let at £76,363.

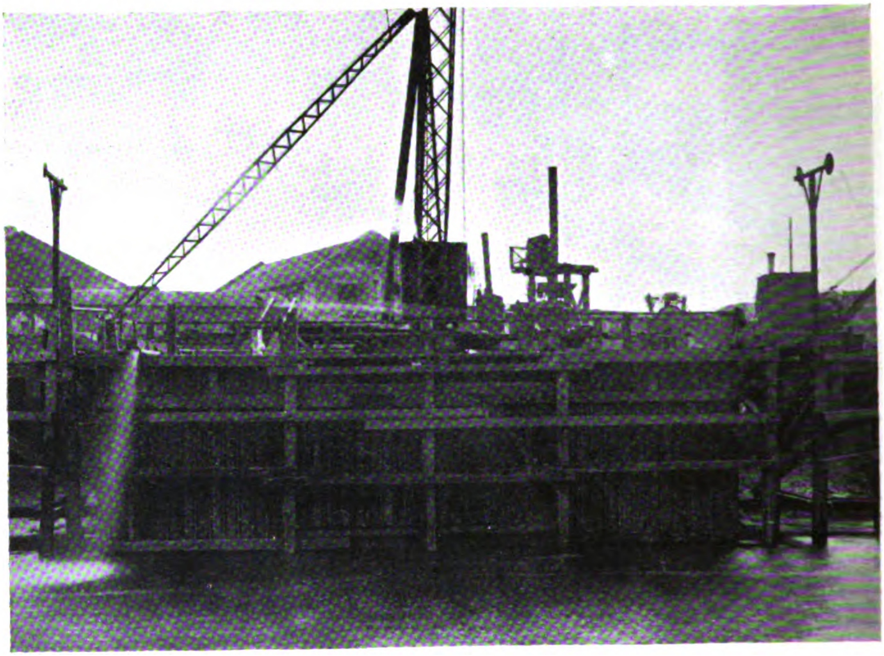
The total length of the viaduct and bridge, measured between abutments, is 670 ft. Of this length the viaduct approach measures 365 ft. and the bridge over the creek 305 ft. The width between parapets is 50 ft.

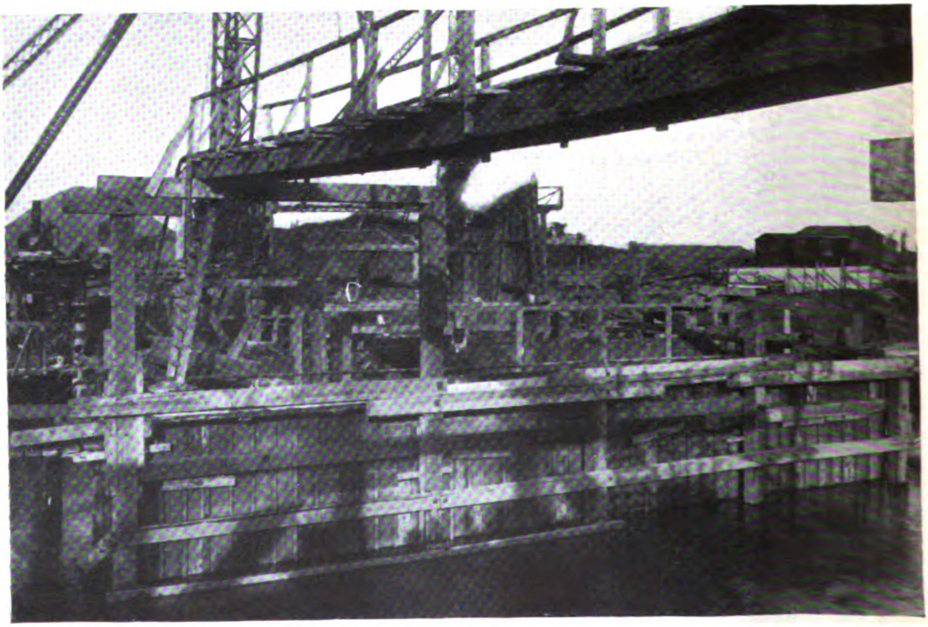
The span of the bridge over Jenkins Lane is 45 ft., while the average span of the viaduct connecting this bridge with the bridge over the river is 36 ft. The bridge over the river consists of three spans of 69 ft., 80 ft., and 69 ft. respectively.

The abutments, the bridge over Jenkins Lane and the viaduct are all founded upon reinforced concrete piles driven into a hard gravel foundation, and varying in length from 9 ft. to 40 ft. These are tied and braced together by means of reinforced concrete ties just below ground level, and are surmounted by the columns of the bridge and viaduct and by the abutment walls.

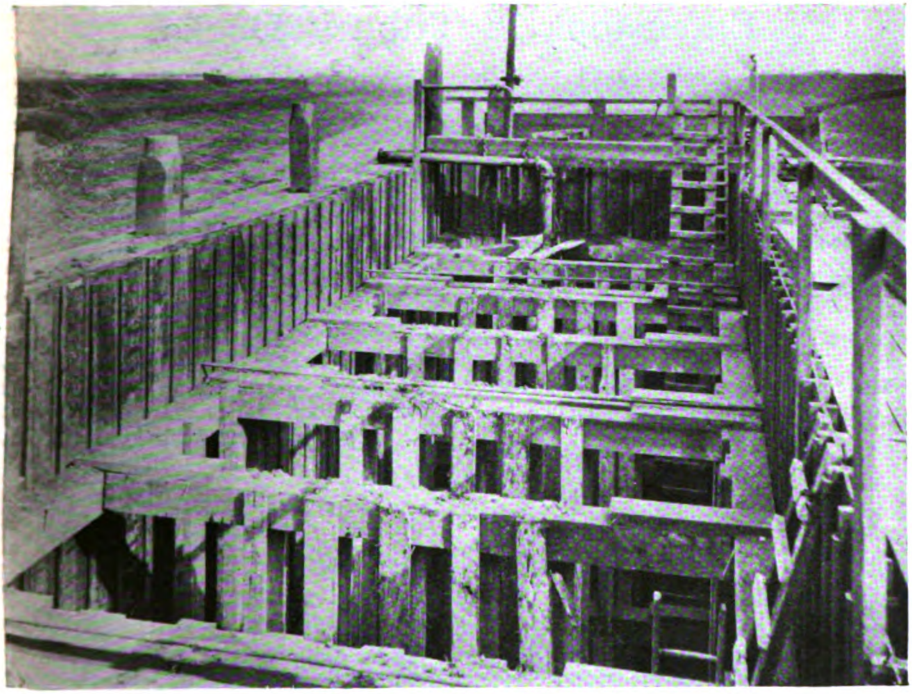
The river piers, however, consist of mass concrete 50 ft. high, 50 ft. long, and 8 ft. wide, except in the lower portion where the width is 15 ft. (maximum). These piers are founded on good stiff clay at a depth of 42 ft. below high water and 28 ft. below the bed of the river; possible dredging conditions, as well as the nature of the ground, had to be taken into account in determining this depth.

The outer river piers take a thrust from the bank and are designed to resist this lateral force as well as to carry the superimposed loads. The construction of these piers was a work of considerable interest, the excavation and concreting being carried out inside dams formed of steel sheet piling 60 ft. in length. The foundations measure 55 ft. by 15 ft., and are carried down to the London clay. These piers were built inside cofferdams formed of 15 in. by 5 in. by 50 ft. "Universal" section steel sheet piling, supplied by the British Steel Piling Co., Ltd., and were constructed two at a time. As soon as the piers were well above high water mark, the dams were dismantled, and the piling of which they were constructed used for the next pair.





Steel Sheet Piling: Section, 15 in. by 5 in. by 50 ft. long.



Strutting inside Cofferdam.

Notwithstanding the depth of the dams, about 47 ft. (excavation was carried to within 3 ft. of the toes of the piles), two pumps sufficed to keep the dams dry. The sheet piles were driven and withdrawn with a McKiernan-Terry automatic hammer.

The width of the roadway is 30 ft., and the two footpaths 10 ft. each. The footpaths are cantilevered out from the transverse beams connecting the outer rows of columns, and the work supporting them is constructed in the form of ducts, approximately 3 ft. deep by 7 ft. wide, allowing room for all necessary cables and mains. The ducts will be filled in with dry material and artificial stone paving laid upon this.

The road formation consists of concrete laid upon the reinforced concrete decking to the necessary cambers and finished with 2 inches of asphalt.

The whole of the structure is of reinforced concrete carried upon four rows of columns which support a beamed decking consisting of longitudinal and cross-beams and decking 7 in. thick.

The construction of the central span over the river was of particular interest owing to the fact that in order that navigation should not be impeded it was not possible to provide supports from temporary piling in the river. Consequently the whole of the shuttering had to be suspended from above. This was done by means of eight composite timber trusses of 80 ft. span constructed on the site (owing to the coal strike it was impossible to obtain steel trusses), and very careful precautions had to be arranged to provide against or take up the deflection in these trusses as the work proceeded and the loading increased. Great attention was given to this matter by the engineers and contractors, and the results verified their calculations and expectations.

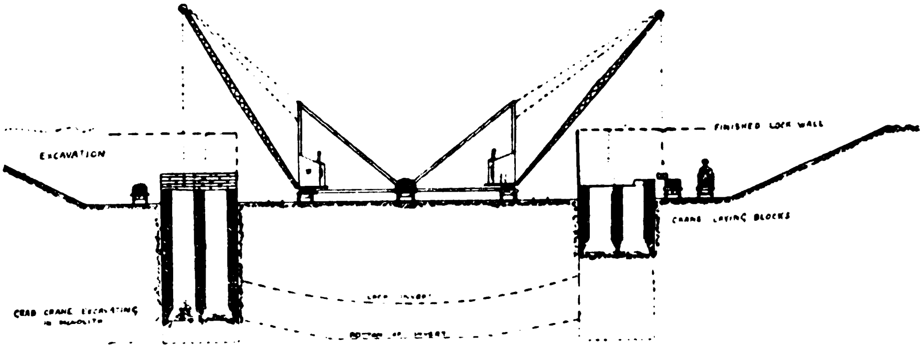
Expansion joints, consisting of complete severance, are provided at intervals in the length of the work, additional expansion joints being formed in the parapet at every second pier.

A detailled account and further illustrations of this important work will be given in a later number.

Extensions at Tilbury Docks.

Rapid progress is being made with the construction of the new entrance lock in connection with the extensions at Tilbury Docks. This entrance will be 1,000 feet long by 110 feet wide, with a depth of 45 feet 6 inches below T. H. W. Within four months 3½ million cubic yards of earth have been excavated by digging or dredging, about 300,000 cubic yards of concrete have been made, and 1½ miles of concrete monoliths driven. Drag-line excavators are being used for the excavation.

The form of quay wall construction to be employed at the new entrance lock and dry dock is known as "Monolith" construction. These monoliths consist of large built-up concrete block boxes, 30 ft. square, having four inside wells, with under-shoes of steel and concrete to form a cutting edge to force a way through the ground.



Monolith Wall Construction at Tilbury.

In this method of construction the site is first partially excavated, say, to 25 ft., and from this level the monoliths are sunk by continuously loading the sides with cast-iron kentledge blocks each up to 7 tons in weight, as much as 1,000 tons weight being placed on one monolith. To assist the sinking, the earth which is forced within the monolith walls is simultaneously grabbed out by a grab crane working from the top. As depth is obtained additional heightening courses of blocks are built up, and this process is repeated until ballast stratum is reached, which may take a period varying from four to twelve weeks or longer. The structure then becomes more or less stationary and the monolith may be considered founded.

The monoliths are sunk contiguous to each other along the line of quay, and when the chain is complete the hollow wells are filled with concrete filling and sealed, the whole forming a continuous solid concrete foundation when the intermediate spaces are filled. On this foundation the superstructure of the quay walls proper is built up of mass concrete and the desired working quay level obtained by filling behind the wall. Monolith construction avoids the alternative method of deep excavation in timbered trench.

The monolith course blocks are cast in wooden forms at a special block-making yard, where they are allowed to mature before being transported to the site for use. Each block is numbered and recorded so that the monoliths may be accurately and properly made, as a faulty block might cause much difficulty through fracture or wrong alignment when a monolith is being sunk.

It is anticipated that the work will require about 190 monoliths, involving the manufacture of 32,000 concrete blocks. The contractors are Sir Robert McAlpine & Son, Ltd.

Concrete Roads in the United States.

1926 Practice in New Jersey.

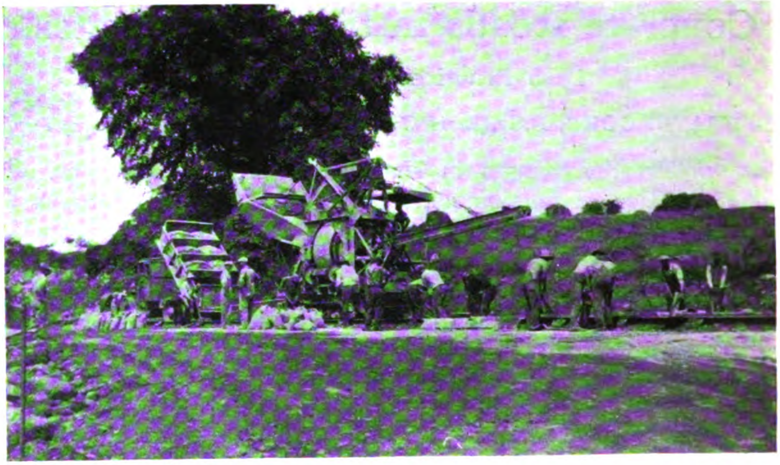
By **W. L. BRAYBROOKE, B.Sc.** (*Resident Engineer New Jersey State Highway Department*).

THE most noteworthy changes in New Jersey practice over previous years are in the direction of obtaining more uniform concrete. Previous to 1926 specifications called for a 1 : 1$\frac{3}{4}$: 3$\frac{1}{2}$ mix by volume with a minimum cement content of 6·40 bags per cubic yard. This cement content was calculated on an assumption of 40 per cent. voids in the coarse aggregate, which is about the minimum percentage that can be obtained with ordinary care in grading of gravel. But until 1925 the specifications for coarse aggregate allowed the inclusion of material which (especially in the case of crushed stone) often ran to 50 per cent. or even 55 per cent. voids. The consequence was that on most jobs there were large "overruns" of cement and the contractors were under the impression that they were being unfairly treated. In the 1925 specifications some attempt was made to remedy this by stricter requirements in the grading of the coarse aggregate.

Last year the following practice was instituted and seems to be working to the general good. The "mix" remains the same, but no minimum cement content is specified. The inspector at the loading plant makes frequent tests of the void content for the aggregate being used, and the theoretical quantity of cement for the day's run is calculated from these figures. Thus it pays the contractor to obtain well-graded aggregate, for then his cement content will be low. A well-graded coarse aggregate, remaining approximately constant, ensures a dense uniform concrete.

The tests made by the plant inspector for void content are quite simple. Ten or twelve times during the day he takes a fair sample of the coarse aggregate either from the portion of the stock pile then being used or directly from the truck that is hauling the batch to the job. He shakes this sample to refusal

Loading Plant.



General View of Operations.

Striking off 2-in. Layer preparatory to placing Reinforcement.

Tamping.

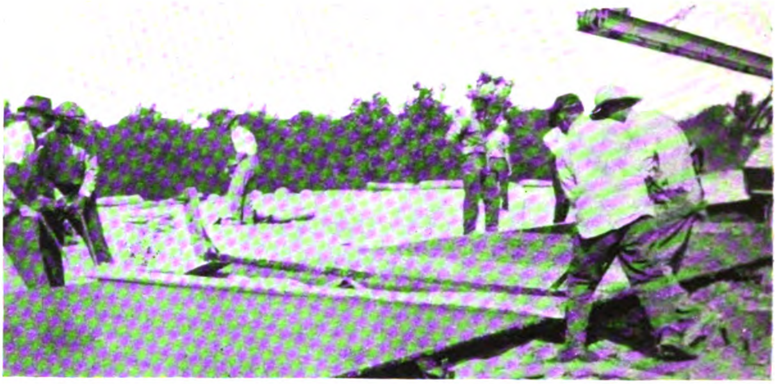
Weighing and Loading.

and takes the weight of ¼ cubic foot. He then consults a table, of which an excerpt is given here, and notes the void content corresponding to the shaken weight as found. The average from all the day's tests is used by the engineer in calculating the theoretical cement content.

Shaken Weight per ¼ cubic foot. Lbs.	Per cent. voids in coarse aggregate.		
	Gravel.	Trap.	Dolomite.
24½	45	50	47½
24¾	42½	50	47½
25	42½	50	47½
25¼	42½	50	45
25½	42½	47½	45
25¾	42½	47½	45
26	40	47½	45
26¼	40	47½	42½
26½	40	45	42½
26¾	40	45	42½
27	37½	45	42½

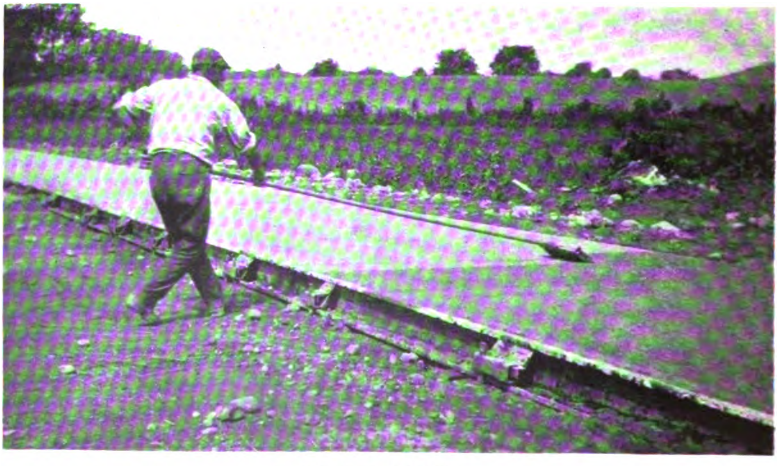
An allowance has been made in these tables for the fact that the coarse aggregate as it is loaded for the job is not shaken to refusal and hence contains a greater percentage of voids. For example, the actual percentage of voids in a shaken weight of 26¼ lbs. of gravel is probably about 38, but in the same gravel as it goes to the mixer the void content is nearer 40 per cent.

In addition to the above practice as regards the coarse aggregate, care is now taken of the sand. Here one has to consider the bulking of wet sand, which has previously militated against uniformity and been the cause of much unnecessary excess of cement.



Planing.

Belting.



Broom Finish.

First of all the weight per cubic foot of dry sand is obtained. As all the sand for any particular job generally comes from the same pit, this dry sand weight is a constant. At least once a day ¼ cubic foot of the sand being used from the stock pile is weighed. A comparison of this weight with the weight of an equal volume of dry sand gives the volume of stock sand required per batch to give the correct proportion of dry sand. For example, suppose the sand weighs 100 lbs. per cubic foot when dry, and the weight of ¼ cubic foot taken from the stock pile is 21 lbs., then the volume of sand per batch must be increased 19 per cent. A variation either way of 1 lb. per cubic foot being allowed, it is found that the sand hopper has very seldom to be changed after being once properly set for the particular sand being used on the job.

The writer is at present in charge of the first highway job in this State where the aggregates are batched by weight instead of volume. Although this method has been used in some of the Middle Western States for three years, it is a novelty in New Jersey. Its advantages are: (1) a greater degree of uniformity in the concrete, (2) no worry about sand bulking. Having once obtained the weight of the dry sand required for the batch this weight remains constant, for the weight of moisture absorbed in the bulking process is negligible, being well within the allowed 4 lbs. variation per cubic foot.

The weighing apparatus consists of a divided hopper suspended by levers which are connected with a scale of the steelyard type. The coarse or fine aggregate is allowed to run into the measuring hopper through roller gates operated by handles, so arranged that if necessary one man can watch the scale and operate the gates. In operation the rider on the scale beam is set at somewhat less than the required weight, the coarse or fine aggregate (as the case may be) is allowed to enter the hopper until the beam tips, then the quantity is brought up to the required amount by small movements of the operating handle.

For example, for a six-bag batch (1 : 1¾ : 3½ mix), weight of gravel and sand each 100 lbs. per cubic foot. For gravel the rider is first set at 2,000 lbs. and then the additional 100 lbs. is run in more slowly. In the case of the sand (which does not run as freely) the first setting is 875 lbs., and the second 1,050 lbs. The two quantities can be weighed and discharged into the hauling truck in 1½ minutes. An additional advantage of the weighing system is that a change of mix (as when 1 : 2 : 4 concrete for headwalls is required) can be taken care of without any adjustment of the measuring hopper as is necessary when the volume system is used.

The following examples of daily runs on the writer's job illustrate this matter of uniformity. The actual number of bags used for each slab (10 ft. wide by about 45 ft. long) is also counted, and it is found that there is practically no variation.

Shaken weight of ¼ cu. ft. (average for day). Lbs.	Per cent. Voids.	Sq. yds. of Pavement.	Cement Required. (Bags.)	Cement Used. (Bags.)	Excess. (Bags.)	Shortage.
26·5	40	910	1,294	1,295	1	—
26·4	40	1,062	1,511	1,507	—	4
26·3	40	1,193	1,696	1,717	21	—
26·3	40	960	1,365	1,365	—	—

TOTALS TO DATE.

Square yards of Pavement.	Cement Required. (Bags.)	Cement Used. (Bags.)	Excess. (Bags.)
19,591	27,862	27,919	57

1926 SPECIFICATIONS: NEW JERSEY.

COARSE AGGREGATE.

	Total per cent. Passing				
	2½ in.	1½ in.	¾ in.	½ in.	¼ in.
Concrete Size Gravel . .	100	40–70	—	0–12	0–2
„ „ Stone . .	100	40–70	0–15	0–10	0–5

CONCRETE SAND.

Passing.	Retained on	Minimum. Per cent.	Maximum. Per cent.
½ in. Screen	¼ in. Screen . . .	—	5
½ in. „	10-mesh Sieve . . .	5	25
¼ in. „	10-mesh „ . . .	5	25
10-mesh Sieve . . .	30-mesh „ . . .	30	60
30-mesh „ . . .	50-mesh „ . . .	20	40
50-mesh „ . . .	200-mesh „ . . .	5	25
200-mesh „ . . .	—	—	5

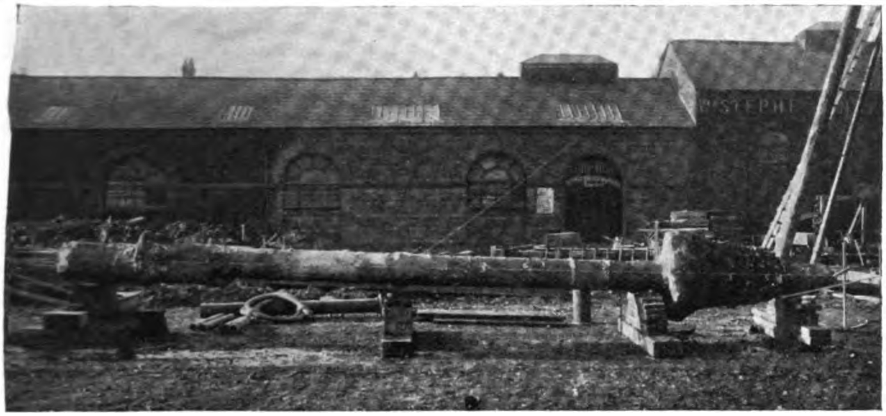
Contraction and Expansion of Concrete.

A MICROSCOPIC examination of concrete under contraction reveals cracks about 0·01 mm. in width followed by cracks of a magnitude of about 0·04 mm. which are visible to the naked eye.

An ordinary 1 to 5 concrete, with a strength of 2500 lbs. per sq. in. at 28 days, shows the microscopic cracks with 0·1 per cent. expansion. Cracks visible to the naked eye appear in plain concrete when the expansion is 0·14 per cent., and in reinforced concrete at the higher value of 0·18 per cent.

Recent experiments, described in "Zement," prove that the cracks appear at a much earlier stage than was formerly suspected.

The question of how to prevent cracks due to hardening is of great importance in the construction of concrete roads, tanks, and long slabs. It has been found that the alternation of wet and dry weather is responsible for changes in length of the magnitude of about 0·3 to 0·4 per cent. It is essential to keep the concrete damp while the hardening process is taking place. Concrete maintained damp exhibited a contraction of only 0·08 per cent., compared with 0·32 per cent. for concrete which was allowed to dry.—W. S. G.



Pile after Extraction.

New Method of Piling at Belfast.

THE Customs House at Belfast is a large and heavy building, the walls of which are built of masonry. The basement is vaulted in masonry and brickwork.

The building is carried on foundations composed of heavy stones supported by timber beams and piles. The piles were driven through soft ground known as "sleech," which covers large areas of Belfast.

Some years ago portions of the building started to sink, and recently it was decided that most of the building was in an unsafe condition. Investigations showed that the timber beams and piles had in many cases become unsafe.

The introduction of reinforced concrete piles driven in the usual manner might have caused the collapse of the structure, and in any case the vaulting in the basement would have made such piling impossible or at least extremely costly and dangerous.

Sir Robert McAlpine & Sons, the

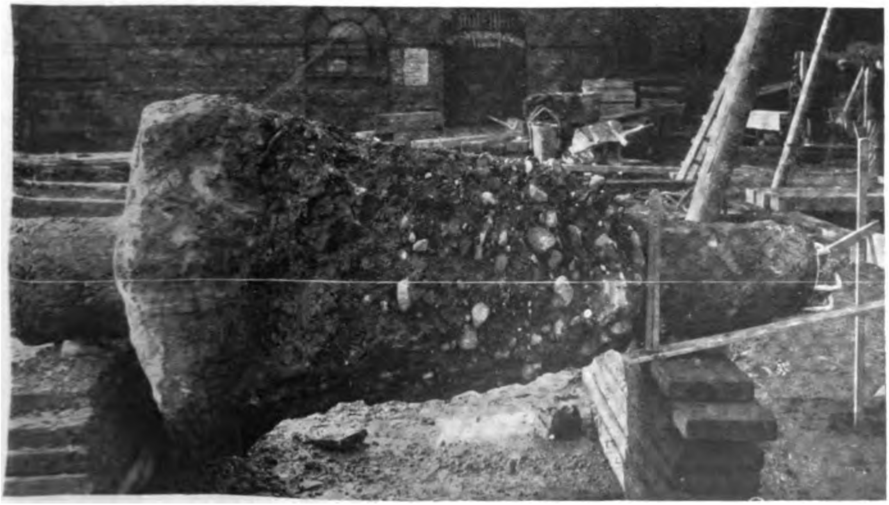


Fig. 2. Head of Pile after Extraction.

licensees of a system of reinforced concrete piling known as the "Concrete Pressure Pile," put forward to the Government a scheme for a new foundation for the building. After a thorough investigation by trial on the site, Sir Frank Baines, H.M. Director of Works, recommended and obtained approval for the employment of this firm on the work of providing complete new foundations for this heavy and large building.

The work involved is as follows:—

(1) The introduction of reinforced concrete pressure piles at short distances apart in pairs, generally with one pile on the outside of the wall and the other on the inside, both exactly opposite to each other or as nearly as possible and close to the edge of the foundation stones.

(2) The tops of these piles are connected together by a strong reinforced concrete beam for the whole length of the wall.

(3) Upon these beams, pre-cast reinforced concrete beams are laid transversely, with their tops a few inches below the bottom of the existing foundation stones.

(4) Steel plates and wedges are then introduced and the whole of the foundation thoroughly wedged up.

(5) The whole of the voids are then grouted.

(6) The walls above the foundation to the top of the vaulting are then sufficiently bored to admit of cleaning out the interstices internally by water under pressure, and then grouting by cement under pressure.

(7) Where possible, old mortar joints which have perished are cleaned out, and in some cases stones which have partially slipped out of position are jacked up and treated by cementation.

The piles are of an average length of

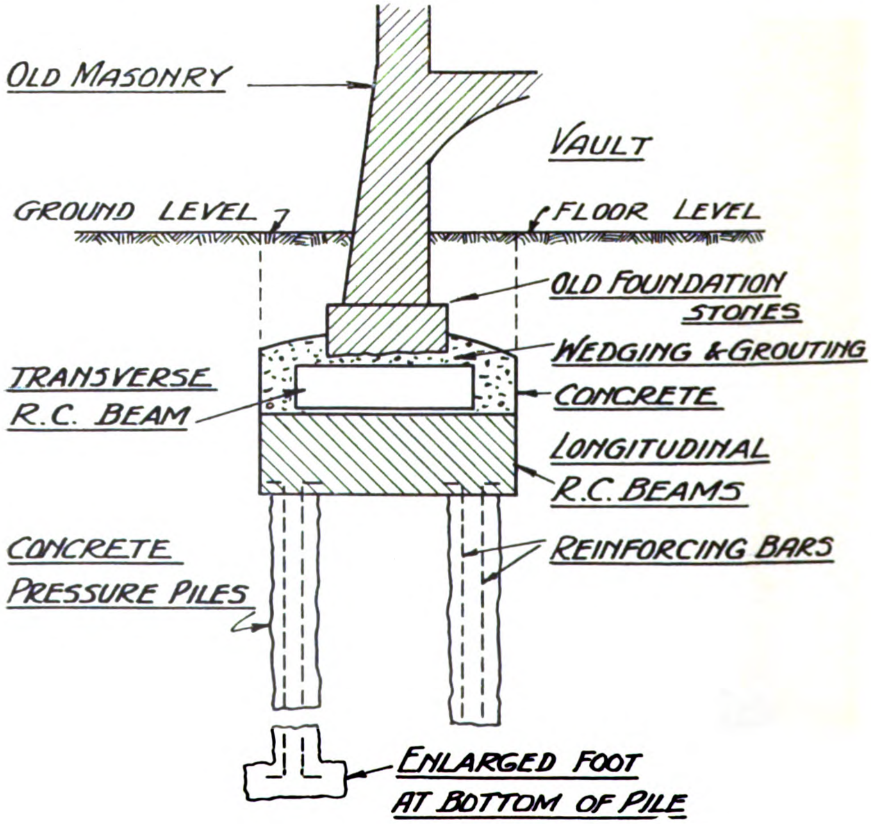


Fig. 3.

approximately 39 ft., and are put in place without any vibration. They are sunk by means of 12-in. diameter steel tubes of short lengths screwed one into another to make up any length required. These tubes are worked down by hand, the earth being taken from the inside by means of scoops fixed to rods and operated by light mechanical plant.

When the bottom of the tube has reached the hard bed on which it is desired to found the pile, the tube is cleaned out entirely and the reinforcing bars (in this case six steel rods each ¾ in. diameter and bound spirally by ¼-in. diameter steel) placed inside the tube. A steel cap with valves is then screwed on to the top of the tube, and any water inside is then blown out (through a valve) by air pressure.

Grout is then poured in and blown out of the bottom of the tube by air pressure, and an enlarged foot is thus formed. Concrete is then poured into the bottom of the pile and after the cap is refixed is then forced by compressed air to the desired pressure (in this case about 100 lbs. per square inch). The tube is then raised, but care is taken that the top of the concrete inside the tube is at all times considerably above the level of the bottom of the tube.

These operations are repeated until the whole of the tube is extracted and the concrete pile is wholly formed.

Investigations have shown that, although the internal diameter of the tube is 12 in., the average diameter of the finished concrete pile is about 14½ in., and the outer surface is not regular but takes such shape as the ground permits, with a hard and compact outer skin. The steel reinforcement is thoroughly surrounded and protected with concrete, and the pile has a large carrying capacity.

The material used is "Ferrocrete" rapid-hardening Portland cement, clean coarse sand of a gritty nature, and hard blue stone graded from ¾ in. to ¼ in.

A test pile of the kind described was recently sunk in a vacant site in Belfast, and on test successfully withstood a load of 43 tons for several days; it has now been dug up for inspection and is illustrated in *Figs.* 1 and 2.

At the Customs House, Belfast, a considerable portion of the piling, underpinning and wall grouting has now been completed.

Fig. 3 shows the general character of the piling and underpinning, while the extracted test pile is shown in *Figs.* 2 and 3.

Gauging Water for Trass Mortars.

THE strength of trass mortars changes rapidly with variations in the amount of gauging water, so it is essential that the quantity of water to be used be specified when tests are being carried out on standard mortars, otherwise the results of different tests will not be comparable. A series of tests carried out by C. Rothert, and described in "Zement," shows this variation very clearly.

Test specimens in the form of cubes were made in the proportions of 1 part of trass to 0·8 part of powdered lime to 1·5 parts of standard sand. The Böhme hammer apparatus was used for compacting the specimens, the number of blows struck being 150.

The results were as follows:—

Mortar.	Water per cent	Compressive strength (Kg)
Rhine Trass (A) + Lime (A)	13·0	184
	13·5	202
	14·0	215*
	14·5	180
	15·0	148
Rhine Trass (B) + Lime (A)	12·0	226
	13·0	270*
	14·0	230
Rhine Trass (B) + powdered lime	11·0	240
	11·5	263*
	12·0	221
Bavarian Trass + Lime (B)	13·0	144
	14·0	235*
	15·0	211

Asterisks are placed opposite the maximum strength figures for each group.

It will be seen how greatly a variation of 0·5 per cent. in the amount of water used affects the strength of the mortars.—W. S. G.

Practical Opinions on New "Formwork" Book.

We give below some opinions we have received from purchasers of our latest book, " Design and Construction of Formwork for Concrete Structures," * by A. E. Wynn, B.Sc., A.M.Am.Inst.C.E., of which a large number have already been sold. The book comprises 320 pages, and is copiously illustrated with drawings and photographs. Designs are given for formwork for every type of concrete structure, from simple footings to arch bridges, and many tables from which sizes of timber for any shuttering purpose may be seen at a glance. Costing data is given for every type of work, and chapters are included on Flat Slab Construction, Steel Forms, etc. The price of the book is 20*s*. (by post 9*d*. extra).

From the

British Reinforced Concrete Engineering Co., Ltd.

This is the most comprehensive treatise on the subject we have seen. For the first time it brings into one volume the existing information on a subject which is becoming of increasing importance to all who are interested in obtaining efficiency and economy in concrete design and construction.

From

Robert Colhoun, Builder, Londonderry.

This book should be in the hands of every builder, and should be a text-book in technical schools. I have received much useful information from it, which has helped me to simplify the construction of shoring and temporary work. I have shown it to one of my principal foremen, who also appreciates it. The section dealing with costs is quite within the experience of actual fact, and is a useful guide.

From

Comben & Wakeling, Ltd., Builders, Wembley.

We consider this to be a very useful and comprehensive work of reference, which fills a long-felt want.

From

Mr. David A. Donald, Chief Engineer, Glasgow-Edinburgh Road.

The tables giving dimensions of formwork members for many usual purposes are very useful, especially to those who have had no training in mathematics.

From

Galbraith Bros., Ltd., Builders, London.

We consider this book absolutely essential to any engineer or contractor engaged on the erection of concrete work. The design tables are invaluable, and the photographs extremely clear and practical. The data and labour costs are of great value in estimating. We consider the price extremely reasonable.

From the Bulletin of the

Indented Bar & Concrete Engineering Co., Ltd.

This book should be of inestimable value to designers and contractors. In addition to its essentially practical nature, it establishes the subject of formwork on a scientific basis. It covers the entire field of construction, is copiously illustrated, and provided with folders and tables which give at a glance the scantlings required and their mode of use. The author deserves the sincere gratitude of the entire building industry for the compilation of an exceptionally thorough treatise. It is one of those books no builder can afford to be without.

From

J. B. Johnson & Co., Ltd., Builders, Liverpool.

This is a very comprehensive work, which should be studied by all concrete contractors. The sections devoted to the theory and design and the strength of centering are especially valuable. The tables are very simple and the illustrations clear.

From

The Reinforced Concrete Construction Co., Manchester.

The book particularly appeals to us for its examples of shuttering and centering for the heavier class of work, such as bridges.

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* Published by Concrete Publications, Ltd., 20 Dartmouth Street, Westminster, London, S.W.1.

From

Mark Round & Sons, Limited, Builders, Dudley.

We feel sure the knowledge gained from this book will prove extremely useful.

From

Joseph Wheater, Ltd., Builders, Bradford.

Undoubtedly this is a very valuable publication, with extremely interesting and useful information; it should be in the hands of every architect, engineer, and contractor, and especially foremen in the employ of contractors specialising in concrete work.

From

Watkin Williams & Sons, Builders, Cardiff.

We should like to say, for the sake of all others engaged in carrying out concrete work, that in our opinion upon studying this book they will come to the same conclusion as us, namely, that it is very valuable and useful in many ways. We believe this book will help to reduce expenditure on concrete work.

From

Yorkshire Hennebique Contracting Co., Ltd., Dundee.

This book is very useful indeed, especially to contractors, engineers and foremen.

From the

Engineer & Surveyor to the Leadgate U.D.C.

I can honestly say that this book appeals to me as being a most useful book for anyone engaged on concrete construction. To municipal engineers who have to construct their works by unemployed labour it will prove an excellent reference, and will result in a saving of time and worry.—VIVIAN J. HUNTER, P.A.S.I.

From the

Borough Engineer and Surveyor of Taunton.

This book is an extremely interesting one, and supplies a long-felt want to any engineer who has to deal with concrete construction. The illustrations are set out in an extremely clear and simple manner, and the photographs showing methods of shuttering are also of great value. There is no doubt the book will be of the utmost value to engineers who have to formulate schemes at very short notice.—IVOR F. SHELLARD, A.M.Inst. C.E.

One from America.

There is a crying need for a comprehensive work on the subject of forms, and I am sure Mr. Wynn's book will be enthusiastically received.—O. A. STELLER, Editor, "Concrete," Chicago.

Contents of "Design and Construction of Formwork for Concrete Structures."

CHAPTER I.—FORM BUILDING IN GENERAL.
CHAPTER II.—MATERIALS, LOADS, PRESSURES AND STRESSES.
CHAPTER III.—THEORETICAL DESIGN OF FORMS.
CHAPTER IV.—DESIGN TABLES.
CHAPTER V.—DESIGN PROBLEMS.
CHAPTER VI.—DETAIL CONSTRUCTION OF FOOTING FORMS.
CHAPTER VII.—DETAIL CONSTRUCTION OF COLUMN FORMS.
CHAPTER VIII.—WALL FORMS.
CHAPTER IX.—DETAIL CONSTRUCTION OF BEAM AND GIRDER FLOOR FORMS.
CHAPTER X.—FORMS FOR RIB FLOORS AND STRUCTURAL STEEL FIREPROOFING.
CHAPTER XI.—MISCELLANEOUS FORMS IN BUILDING CONSTRUCTION.
CHAPTER XII.—FORMS FOR FLAT SLAB CONSTRUCTION.
CHAPTER XIII.—FORMS FOR CONDUITS, SEWERS AND CULVERTS.
CHAPTER XIV.—FORMS FOR TANKS, SILOS, BINS AND STANDPIPES.
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2. Maximum span of wall sheathing for various heights of wall.
3. Maximum span of column sheathing for various heights of column.
4. Maximum spacing of floor joists for various spans and thicknesses of slab.
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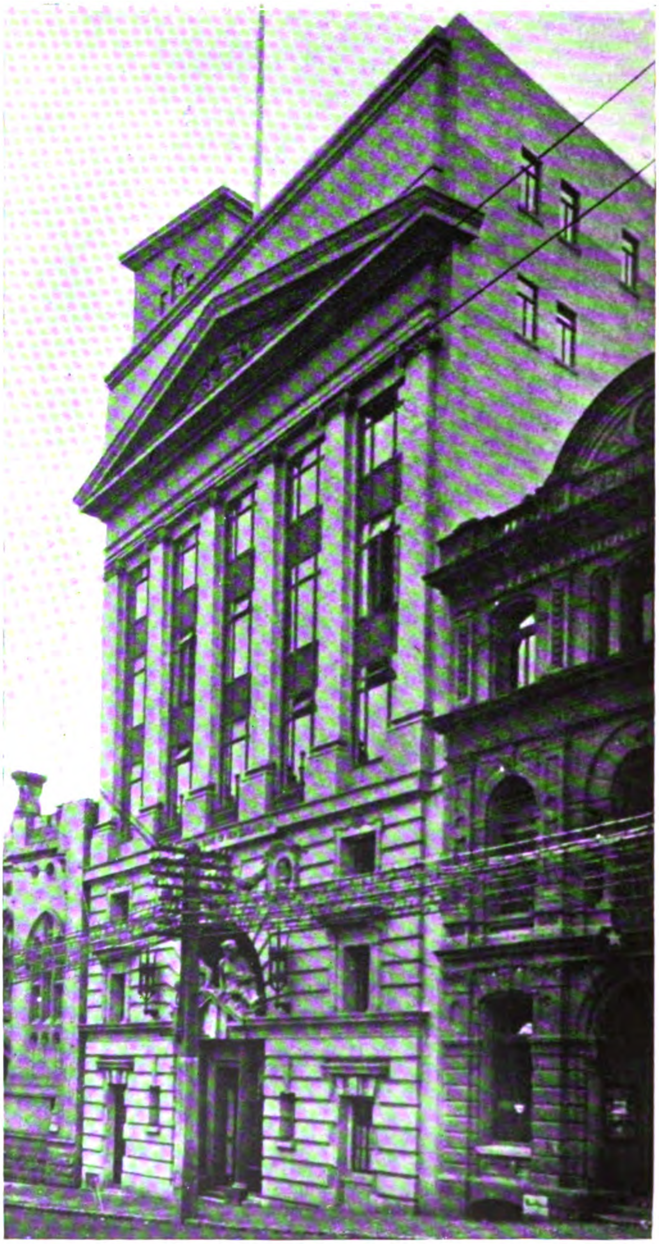


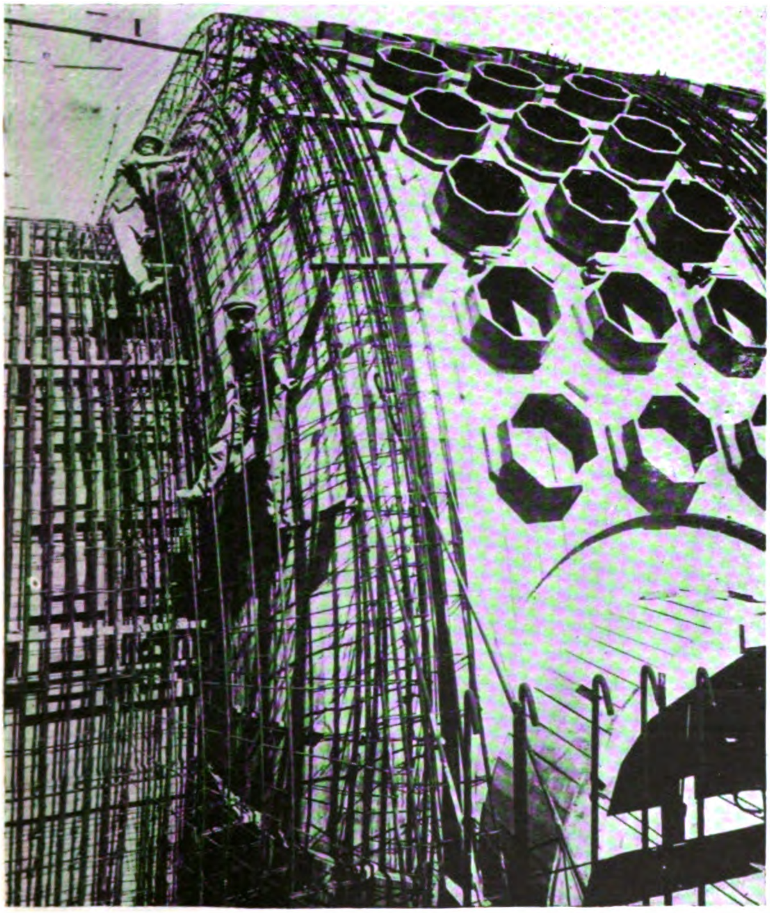
National Bank of New Zealand, Auckland Branch: Shortland Street Front. (*See p.* 143.)

Barrel-Vaulting in a New Zealand Bank.

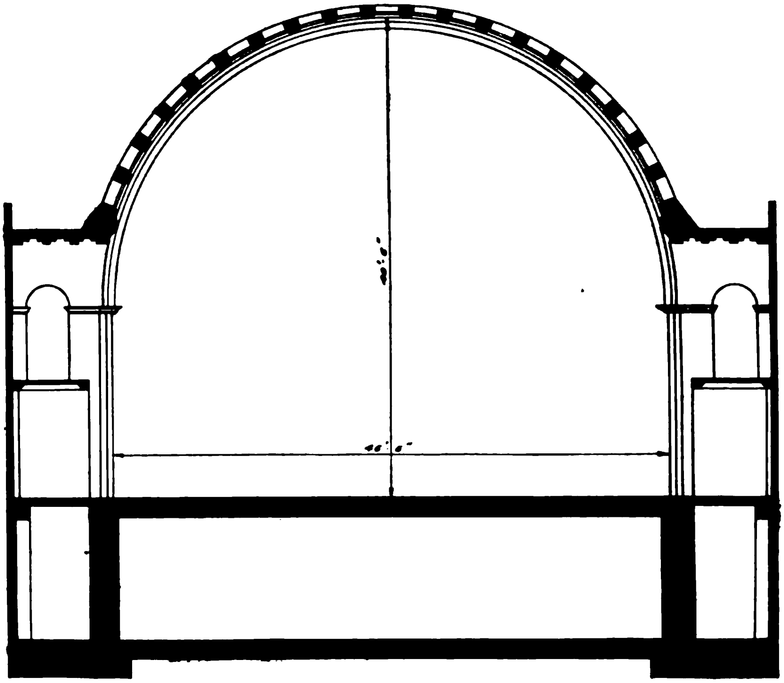
We illustrate the new Auckland (N.Z.) Branch of the National Bank of New Zealand, for which Mr. S. T. Silver, of Wellington, N.Z., acted as consulting engineer. This building is particularly interesting on account of the reinforced concrete barrel vaulting of the banking chamber.

The new premises consist of two separate eight-story buildings, one in Shortland Street and one in Fort Street, connected by the Banking Chamber, which is the main feature of interest from an engineering point of view. This chamber consists of a barrel vault approximately 90 ft. long, 62 ft. wide, and 40 ft. high. Four central arch ribs, rising as columns from the ground floor, extend across in a semicircle from about 16 ft. up, the lower column portion being connected by side arches, while the upper consists of slabs containing numerous octagonal glazed openings. The ends of the chamber are formed by return arches working in to smaller barrels at each end.

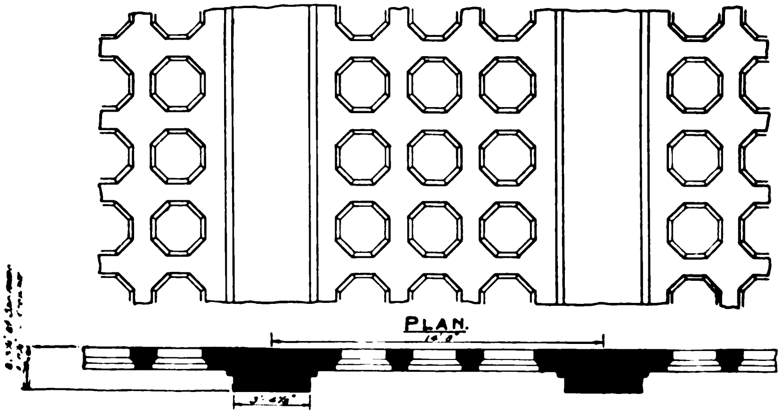
While the main arch ribs were designed to take all the load independent of any other part of the structure, advantage was taken of the flat roof at second-floor level over the side arches to introduce hori-



Placing Reinforcement at End of Banking Hall.



SECTION THROUGH BANKING CHAMBER.



PLAN.

SECTION

BARREL VAULT CEILING SHOWING OCTAGONAL LIGHTING.

NATIONAL BANK OF NEW ZEALAND AUCKLAND BRANCH.

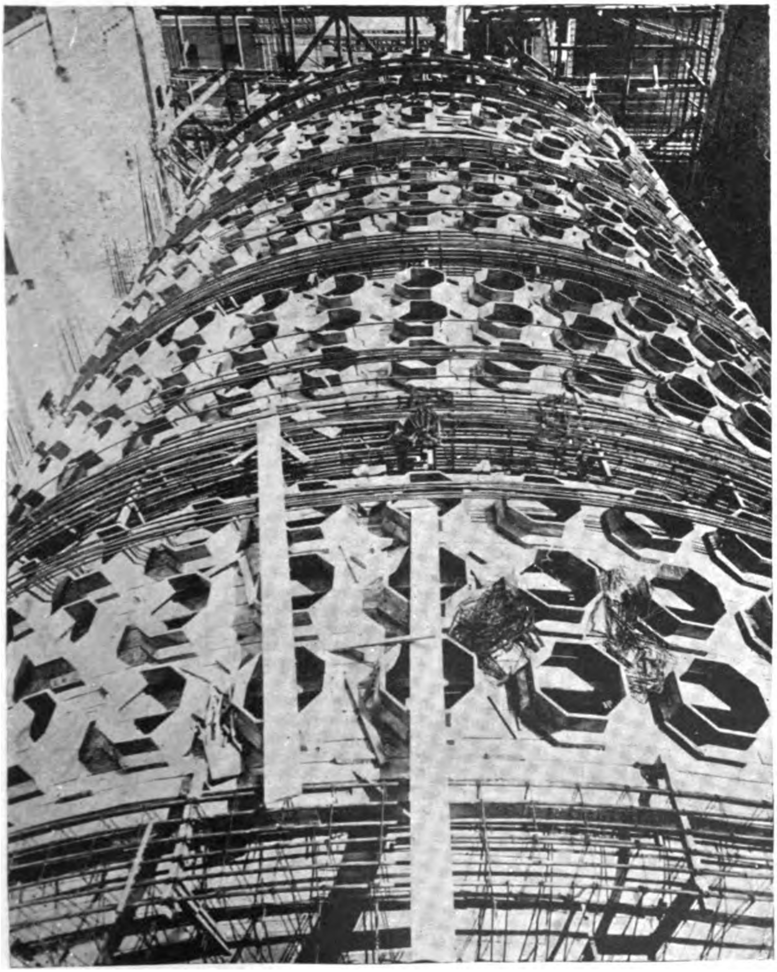
Scale of 4 0 4 8 12 16 feet

zontal trusses capable of transmitting the thrust at this level to the return arches at each end, where there is a substantial body of concrete in a suitable position to act as cantilevers.

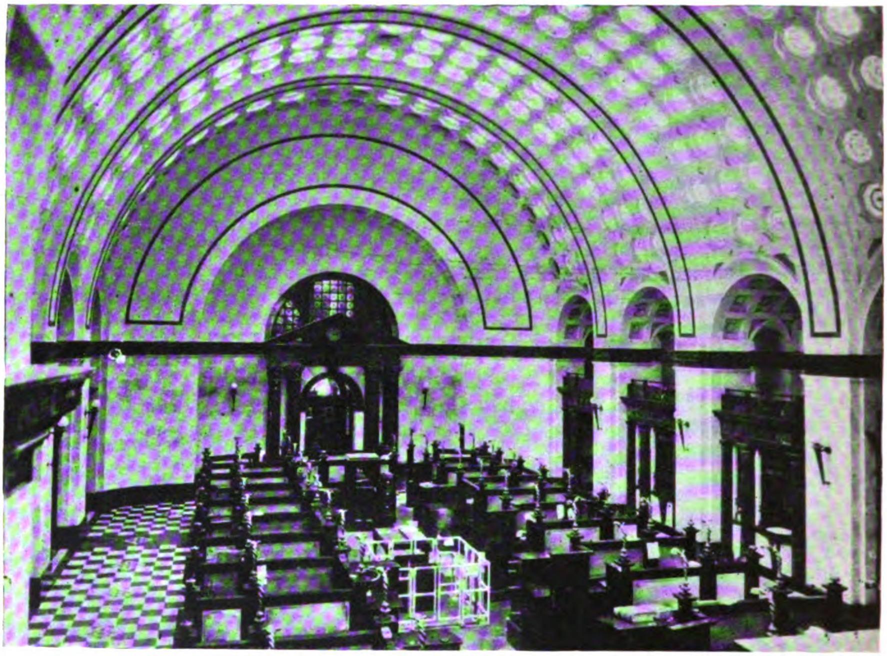
The building fronting Shortland Street is entirely new. In the case of the Fort Street end the front and side walls remain, but the interior brick partitions (except in one or two cases in the lower floors) and timber floors were removed, and reinforced concrete columns and floors substituted; in addition, two extra stories were added. The brick walls remaining, however, do not carry the new floors, concrete columns partly chased into the brickwork being introduced.

The back wall of the Shortland Street building, which extends some distance over the banking chamber, is carried on cantilevers projecting over four columns, two of which are supported on a large beam partly incorporated in the return arch at the end of the chamber; a view of this beam with reinforcing in place is illustrated.

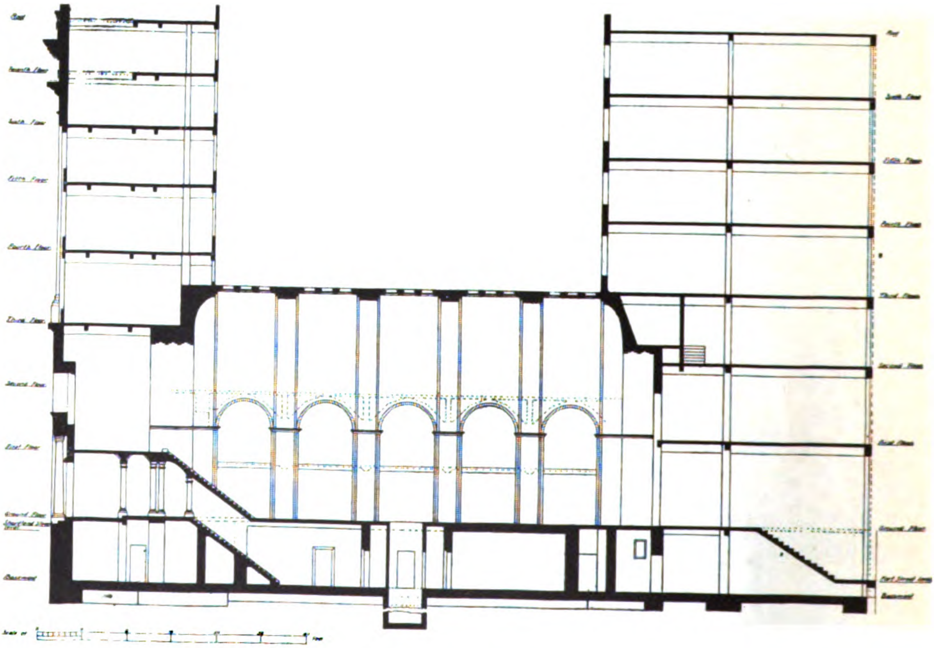
In the case of the back wall of the Fort Street end, extending about the same distance over the banking chamber, columns were carried up from the large



Boxing for Barrel Vault.



Interior of Banking Hall.

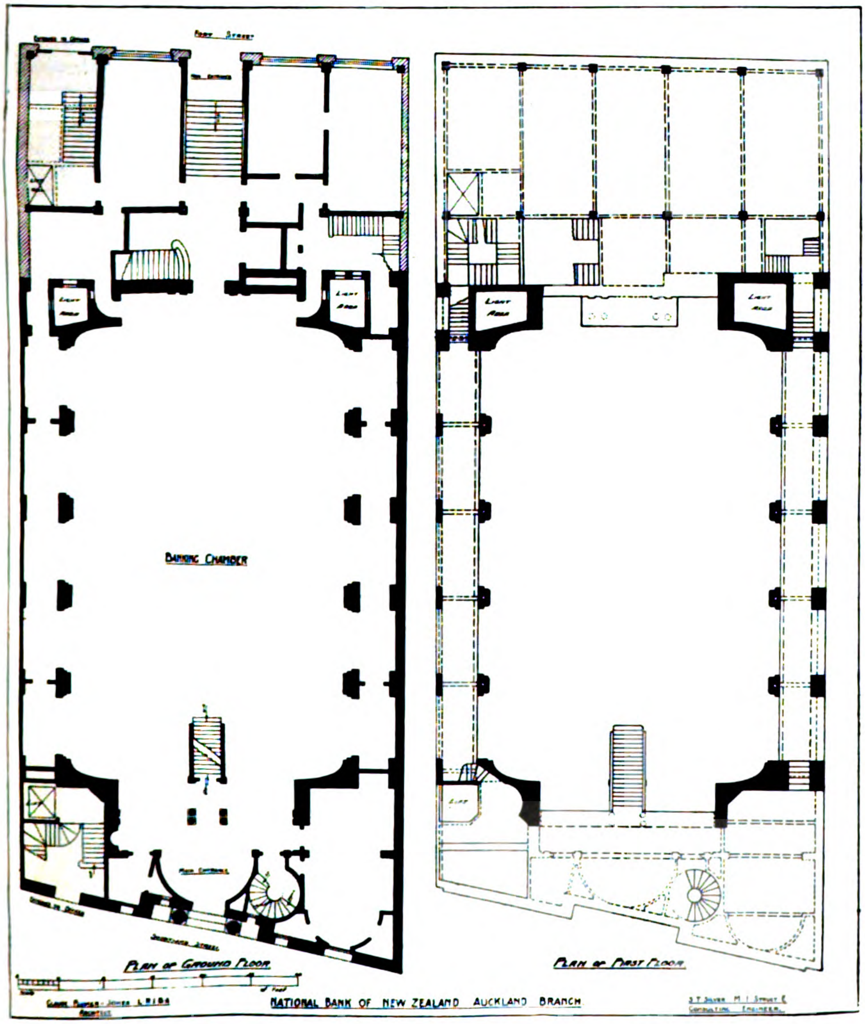


LONGITUDINAL SECTION ON CENTRE LINE.

walls at light area on each side, and the short side walls are employed as cantilevers all the way up and support the large back wall beam at each floor level. The decision to alter the Fort Street end was come to only when the first portion was nearing completion, necessitating different treatment.

The foundations are in somewhat soft ground and consist of a reinforced concrete raft over the whole site, of varying thickness according to the loads to be carried. The banking portion of the building is entirely independent of the rest, and separate entrances at each end lead to stairs and lifts serving the upper-floor offices. With the exception of the brick walls referred to, the finishing in marble, etc., all the building is of reinforced concrete, and the reinforcement consisted of plain round mild steel bars. The possibilities of New Zealand marble have been amply exploited in the carrying out of the general architectural scheme, and the building is certainly an unusual and exceptional type for N.Z., while modern devices and equipment prevail throughout.

The architect for the work was Mr. Claude Plumer-Jones, L.R.I.B.A., while the work was carried out principally by day labour under the supervision of Mr. A. A. Renner.



Grouting with Cement.

SOME interesting cementation work has recently been carried out at Doncaster Parish Church, a work of the late Sir Gilbert Scott built about 70 years ago. When the stonework of the tower was being restored it was found that much of the ashlar work was of very little depth or bed, in some cases scarcely more than 3 in., and the intervening spaces between the outer and inner ashlar filling consisted of little more than rubbish. The bonding of the stones was also found to be bad, and in quite a number of instances there were mitres worked to a feather-edge and not on the solid. Iron had been used for cramps and dowels, and it was due to this that much of the stonework was cracked.

The space between the exterior and internal facings was composed of indifferent rubble filling, and it was therefore decided by the Fabric Repair Committee, upon the recommendation of their architects, Messrs. Walker & Thompson, FF.R.I.B.A., to call in the services of Messrs. Blandford & Gee, cementation and consulting engineers, of Doncaster. Upon inspection the opinion was expressed that, by means of injection of liquid cement under pressure, the existing spaces among the rubble between the ashlar work could, after carefully pointing the joints, be satisfactorily filled and the whole fabric strengthened to a degree previously non-existent.

An interesting feature in connection with the cementation work is that a start was made at the bottom of the defective portion, the cement being forced upwards. The operation of cementing comprised the drilling of a systematic series of holes through the outer skin of the tower. Pumping operations were then commenced upon the lower series of holes, when the cement grout was forced in until it rose to the next higher series of holes. At this stage connection was made to the latter series of holes, and pumping operations resumed until the whole space from the bottom to the top was filled. Some idea of the nature of the interior of the walls may be gained by the fact that over 12 tons of cement were used in the process of grouting.

The apparatus used consisted of two vertical cylindrical containers connected at the top by a pipe and three-way cock to a cement mixer surmounting them. By manipulating the cock it is possible to fill either container at will. The containers are also connected at the top by a pressure supply pipe, to which is attached a three-way cock, allowing water to be supplied under pressure from a pump, e.g. a hand pump, to either container at will. At the bottom the containers are connected by a pipe and three-way cock to the cementation flexible pipe, through which the cement grout can be forced from one container or the other to the work in hand. Each container is provided at the bottom with a drain cock.

In operation, cement is mixed in the mixer and run into one of the containers, which is empty. The drain cocks, water-supply cocks and cement pipe cocks are closed. When the container is full the mixer cock is closed. The cementation pipe cock and pressure water cocks are then opened and the cement grout forced out of the container through the cement pipe to the work, e.g. cementation of a wall or pillar. The other container, meanwhile, is cut off from the mixer, water pump, and cement pipe. When the water under pressure has driven all the cement grout out of the container the three-way cocks are closed and the water emptied out of the container by the drain cock for use in making up a further batch of cement. The cylinders are used in alternation, so that there is practically a continuous supply of cement grout under pressure. More than two containers or several pairs of containers may be used if desired.

It will be seen that the pressure under which the cement grout is supplied can be controlled at will by varying the pressure of the displacing water. Since only clean water passes through the pumps, there is none of the wear and tear on the parts which would take place on passing the cement grout through them. The apparatus is very compact and especially suitable for hand-work upon scaffolding or in limited spaces. The apparatus is not only applicable to cementation; it may be applied to the supply of other suspended solids in water or other liquids. Pressures as high as 500 lbs. per sq. in. can be conveniently employed.

Ernest Fiander Etchells.

AN APPRECIATION BY EWART S. ANDREWS.

THE tragic passing of Ernest Fiander Etchells on January 5 leaves a gap in our ranks that it will be very difficult to fill; for Etchells was in many respects a remarkable man. Physically he was of massive contour and striking appearance—hewn out of rugged granite, to use an expression that he often adopted himself with a characteristic but rather pleasant rolling of the "r." Intellectually he was in many respects also a giant; he had a remarkable memory and an amazing *flair* for getting hold of obscure matters lying on the borderland of engineering and architecture.

Every one of the very large number of men who came into contact with him must have realised that here was a man who was different from the rest; personality exuded from him, and combined with this quality, which is so difficult to define but so easy to feel, there was in him the power to convince as to his ability and reliability. These are rare attributes, and fitted him well for the difficulties in the official appointment which he fulfilled so successfully at the London County Council. His age—only fifty years—came as a surprise to most of his friends; I have known him for over twenty years and have had the privilege of his intimate friendship ever since. When I first met him I was about to take over from him some evening lectures at one of the London colleges, and we met to discuss the work that he had been doing quite successfully so that I could continue on somewhat similar lines. He was only twenty-seven years of age, but he was even then wearing the beard which in later years had become so familiar, and did not look many years younger than he did in recent times.

His activities can be divided into two streams, those resulting from his official capacity and those resulting from his intimate connection with so many professional societies. As a technical officer in the London County Council he worked for many years under the Superintending Architect of the Council, particularly in regard to the administration of the London Building Acts in connection with Steel Frame and Reinforced Concrete Buildings. For the technical clauses of the 1909 Act dealing with Steel Frame Buildings he was, I believe, almost solely responsible; and although some, including myself, have severely criticised some of these clauses, such criticism has been principally directed to details; all of us recognise that as a whole the Act was a fine piece of work, and experience of its administration by the District Surveyors for nearly twenty years has proved that it worked very smoothly in practice.

I doubt if anybody who has not had experience as a technical officer to a public authority can have any conception of the amount of work an Act of this kind involves. There are necessitated the previous study, digestion, and collation of the various regulations obtaining in other countries; endless writing of minutes and reports; attendances at conferences where people will waste time by talking irrelevances and important persons ask unnecessary questions that involve feverish searching of past records a few hours in advance of the next meeting. Etchells excelled in this kind of work. He possessed the quality, so valuable in a public servant, of being able to "suffer fools gladly," and was moreover willing to burn much midnight oil in mastering his work.

The Reinforced Concrete Regulations, which were passed in July 1915, represented a more ambitious piece of work and involved years of concentrated effort. These Regulations have been subjected to much criticism in the light of later knowledge, but everybody who is in possession of the facts realises that Etchells in drafting them and piloting them through their various channels was prompted by one desire only—to produce a set of regulations which were complete in every detail, would ensure a very high standard of construction, and would be worthy of the great city of which he was a devoted servant. In the past few years he has been engaged upon a revision of these Regulations, and I believe his work was practically completed when a heart attack took him from us.

His other activities which brought him into touch with a large body of men were in connection with professional societies, of an amazing number of which he was an active member. He was this year in the chair of the British Section of the French Society of Civil Engineers, but he will be most remembered in connection with the Institution of Structural Engineers and the Concrete Institute from which it grew. This change of title followed upon an earlier change of scope and was due almost entirely to his own efforts; the wonderful growth of that Institution in the past few years is a great tribute to his foresight and importunacy.

I have previously referred to the fact that his favourite studies were on

New Marine Parade at Ramsgate.

[All-concrete carriageway and footpaths, 6 in. thick, reinforced with B.R.C. fabric. The Borough Engineer is Mr. J. G. Taylor.]

the borderland of engineering ; the standardisation of engineering notation was one of the subjects to which he gave great attention and his efforts have been crowned with success so far as reinforced concrete is concerned in this country. His book on this subject and his presidential address, both published separately by the Institution of Structural Engineers, are both good examples of this aspect of his work.

This memoir is rather on unusual lines, but I feel justified in so presenting it because it deals with an unusual man, and I will conclude with a brief reference to his personal qualities. His most striking quality which made such a marked impression upon all who came into contact with him was a strange blend of opposites ; he was learned yet jovial—even boyish. Whenever he spoke at a meeting he would be certain to give a sudden descent from the sublime to the ridiculous which tickled the fancy of his listeners and made them feel that here was a fellow with a quaint sense of humour. Most of us were in the habit of chaffing him, and he always responded in the right spirit—it is a great testimonial to a man's character that his intimate friends chaff him in public.

He possessed tremendous enthusiasm for everything that he undertook ; if he made one mistake it was of undertaking too much. He relied upon a to-morrow, with the result that he probably shortened his life by over-straining his constitution in trying to keep pace with the work which he had undertaken.

His disposition was a delightfully sunny one—yet his life was not all sunshine ; he had to pass through shadows, but they did not darken his outlook and we will remember him for many years as an outstanding and inspiring figure amongst us, always ready to laugh with us and never refusing to help us with our difficulties.

Mr. Etchells died on January 5 at the age of 50. He held the office of Structural Engineer in the department of the Superintending Architect of Metropolitan Buildings at the County Hall. He was trained at Manchester, Glasgow, and King's and University Colleges, London, and was a pupil of F. L. Lane, of Leeds, and of John Strain, of Glasgow. He was early engaged in designing rolling stock for the Pretoria and Pietermaritzburg Railway, aerial ropeways in Bolivia, and nitrate plants in Chile. Later he was employed on structural work at Motherwell, Lanarkshire, and on the Clyde Valley Electric Power scheme and the City of Mexico Electricity Supply scheme, and since 1902 had been engaged chiefly as an engineer and surveyor under the London Building Acts.

He was a Past President of the Concrete Institute for two sessions in succession, and largely instrumental in changing its title to the Institution of Structural Engineers. At the time of his death he was President of the Association of Architects, Surveyors, and Technical Assistants, in which body he took considerable interest, honorary president of the Association of Floor Constructors, Honorary A.R.I.B.A., and honorary member of the British Engineering Standards Association. For the present year, 1926–27, he was president of the British section of the Société des Ingénieurs Civils de France. Mr. Etchells was also associated with other technical institutions, and was interested in the standardisation of mathematical notation. Quite recently he was devising a method of cheapening the production of mathematical books by the use of ordinary printing characters instead of signs for the expression of formulæ, and in this direction he was working in conjunction with the proprietors of this journal.

Repairing a Masonry Bridge by Injecting Cement.

OUTSIDE the Carcassonne Station of the Chemin de Fer du Midi there is a masonry bridge of a total length of 148 m. and a width of 8 m. crossing the river Aude on the skew at an angle of 65 deg. The bridge consists of five masonry arches, each 18 m. span and 3 m. rise, and two arches each 6 m. span supported by six piers and two abutments.

For a long time cracks had been visible in the masonry and in 1923 all the arches were cracked, generally in a longitudinal direction. The cracks were 3 to 4 cm. in width. Similar cracks were apparent in the piers. A survey of the bridge revealed the fact that some of the cracks ran from the intrados to the extrados of the arches.

Water appeared to be the cause of the defects, and the following precautionary measures were taken in order to make it serviceable:

(1) Injection of cement under pressure into the piers and arches;

(2) Improvement of the drainage arrangements for taking away the rain-water from the floor.

In a recent issue "Le Génie Civil" describes the work of injecting cement as carried out under M. Bouteiller, the Chief Engineer for Works to the railway company.

The holes were drilled by a pneumatic hammer, the drill turning one-sixth of a revolution at each blow of the hammer, which weighed 30 lbs. and worked under a pressure of 7·7 lbs. The average depth of hole was 6 ft. 6 in. Wherever the masonry appeared of a poor quality or damp, or wherever the joints were in a bad state, holes were drilled.

After drilling the holes, air under pressure was blown into them in order to clean out the débris. This operation also helped to give some idea of the openings existing between the different holes. The next operation was the injection of water to wash out the holes. This was continued until only clear water escaped from the openings.

Before injecting the cement the hole was stopped by a pipe caulked with gaskin and, if necessary, fixed by quick-hardening cement in order to prevent an escape of the material pumped in.

Two different methods were employed in the injection process. In the first a steel cone, with a valve, was fixed to an elbow bolted on to the injecting pipe. The cement grout was run into the cone, which had a capacity of about one bucket-full.

The first batch of grout was mixed very wet, sometimes three volumes and never less than one volume of water to one volume of cement. The next application consisted of two volumes of water to three volumes of cement. The object of the first very wet mix was to enable the grout to fill very small cracks at a considerable distance from the drill-hole.

After the hole was considered to be filled the pressure was maintained for 15 minutes to allow the cement to commence to set. As only one bucket of grout can be used at a time the number of injections required to fill a large hole is very large and the operation is prolonged. Also the cone method does not permit of grouting holes drilled upwards or those near the arch springings.

The second method comprises a drum 80 cm. diameter and 40 cm. wide, made of steel plates and mounted on a travelling carriage. Inside the drum, paddles revolve on a horizontal axis. On one side of the drum is bolted a mouthpiece for filling it with grout. Another orifice in the upper side serves for the compressed air, and a third for the pipe leading to the drill-hole.

The drum enables a fairly large amount of grout, about five bucketfuls, to be injected at one operation. The direction of the drill hole is also of no importance; even if the hole is vertical the air-pressure from below prevents the grout from flowing downwards, while another charge is being prepared.

The apparatus has given very satisfactory results. Nearly 54 tons of cement have been used and 623 holes drilled. These figures give some idea of the quantity of voids in the bridge and its piers. The work has proved a satisfactory and cheap method of repairing this bridge.—W. S. G.

Bond between Concrete and Steel.

By W. D. WOMERSLEY, M.A., B.Sc., A.M.Inst. C.E.

In the usual tests for bond resistance between concrete and steel, in which a steel bar is embedded for a certain length in concrete and then withdrawn by the application of an axial pull, there are one or two unsatisfactory features which it has been considered desirable to remove, and consequently the problem has been approached in a slightly different manner.

In the first place, unless the bar to be withdrawn has a diameter reasonably large in comparison with its embedded length a considerable longitudinal stress must be applied in order to move it, and this produces an appreciable diminution in the diameter of the bar, which is variable along the embedded length by reason of the transference of the tensile stress in the bar to shear in the concrete. This means, in effect, that the embedded end of the bar is larger in diameter than the exit end, and since, under certain conditions, the concrete will maintain contact throughout the length of the bar, the exit end of the hole is less in diameter than the remoter parts of the embedded bar. A certain amount of work must therefore be done in the deformation of the bar during its withdrawal.

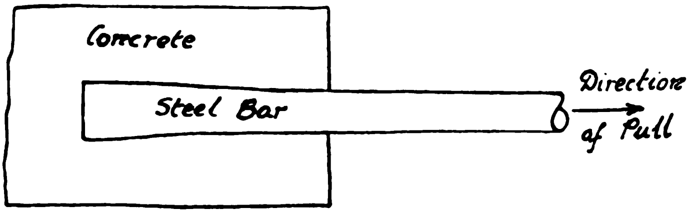


Fig. 1.

It may be shown that the diameter of the bar increases logarithmically from the exit end inwards as shown in an exaggerated manner in *Fig.* 1. If the diameter of the bar is small in comparison with its embedded length, it may be that the exit end may reach its elastic limit in tension and diminish in diameter sufficiently to lose contact with the concrete entirely. Under these conditions the elastic limit stress passes along the bar until the whole of it is released. Many experiments have been carried out in this manner, and in all cases of long embedments—up to 40 diameters—the tensile stress necessary for the withdrawal had this same value, indicating that the true bond resistance was not really being measured.

In the second place, the steel bar is usually cast co-axial with a concrete cylinder and the relation between the diameter of the steel bar and the diameter of the concrete cylinder has a considerable bearing on the results. Since concrete contracts in setting and the rate of setting is proportional to the temperature, and since the reaction is exothermic, it follows that the centre of a mass of concrete during setting will reach a higher temperature than the outer regions and will consequently set quicker; thus the later setting contraction of the outer regions will produce a radial compressive stress in the concrete and steel at the centre. The extent of this mutual pressure between the concrete and steel will affect considerably the frictional force necessary to produce relative movement between the two materials. The radial compressive stresses also produce diametral strains in the steel and concrete, which further complicate the diametral variations discussed.

The process of disengaging a piece of embedded steel from the surrounding concrete consists of two very definite parts which become inextricably mixed together in this method of experiment. Initially there is an adhesive surface action of some kind between the concrete and the steel during setting, and this produces what has been termed the " stickiness " part of the bond. The extent of this effect depends upon the mutual pressure existing between the two materials when setting takes place and also on the intimacy of the contact, produced perhaps by the ramming of the wet concrete on to the steel. When this adhesion has been broken down (and this is more easily done by vibration than by a steady pressure) the friction must be overcome before relative motion takes place. In the pull-out tests these two actions are occurring simultaneously in different parts of the bar.

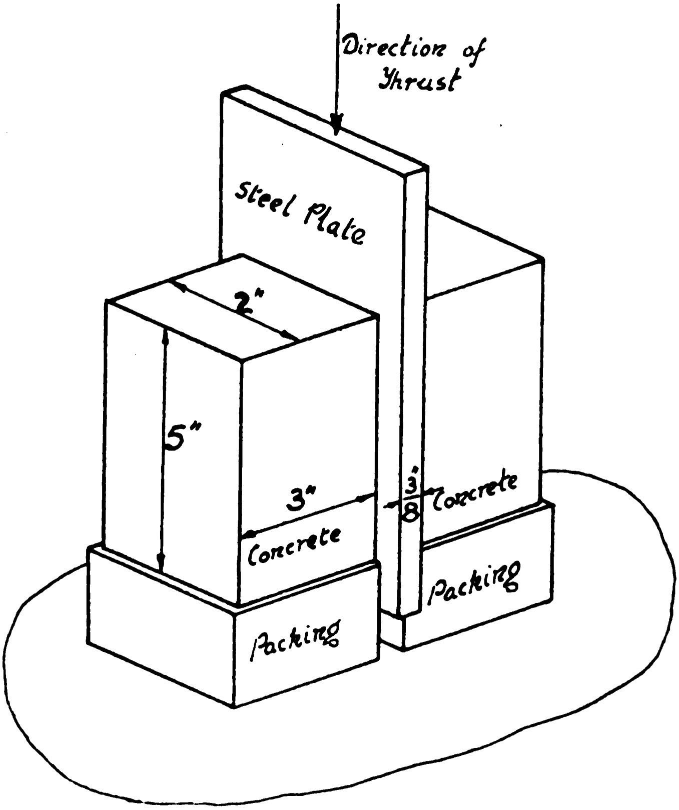


Fig. 2.

Experiments have been carried out in an endeavour definitely to separate the two parts and to determine, if possible, the extent of the contraction compressive stress initially set up. The concrete used in the experiments consisted of granite chips and sand and rapid-hardening Portland cement, the mixture being in the same proportions as that in the compression specimen C described in *Concrete and Constructional Engineering* for April and May, 1926. All the tests were carried out at 7 days.

In the first series of experiments a steel plate was set up vertically and two rectangular blocks of concrete cast, one on each side, and independent of each other in order to prevent any possibility of contraction stresses occurring between the concrete and steel. The arrangement is indicated in *Fig. 2.* It was set up in the testing machine resting on the two concrete blocks with suitable resilient packing, and the steel plate was pushed down between them. The plate was of rolled mild steel with the rolling scale intact, and thus presented a very smooth and hard surface to the concrete. The results are as under :—

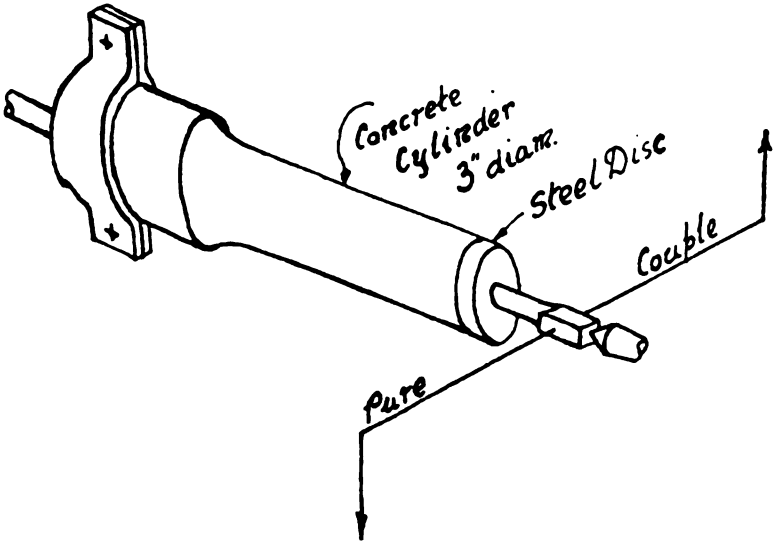


Fig. 3.

TABLE I

Experiment No.	1	2	3	4	5
Tangential Stress lbs. per sq. in.	79	72	68·4	99·4	85·5

Average 80·8 lbs. per square inch.

In the second series of experiments, 3-inch diameter concrete cylinders were cast with their axes vertical and with their bases resting on hard steel discs the surfaces of which had been filed quite smooth. These specimens were set up in a torsion testing machine and the steel discs twisted off by the application of a pure couple as shown in *Fig.* 3. In these tests, again, there is no setting contraction causing pressure between the two materials, but there is more intimate contact produced by the vertical ramming of the wet concrete directly on to the steel discs. Under these conditions, and on the assumption that the adhesion is uniform over the surface of the disc, if f is the tangential stress and T is the couple necessary to overcome it, then

$$T = \int_0^r f.2\pi x^2.dx$$

where r is the radius of the cylinder. Thus since $r = 1{\cdot}5$ inches

$$f = {\cdot}1415.T \text{ lbs. per square inch.}$$

The results obtained are as under :—

TABLE II

Experiment No.		1	2	3	4	5	6
Couple T . . .	Lbs.-inches	504	558	810	864	900	1440
Tangential Stress f .	Lbs. per square inch	71·3	79	115	122	127·5	204

Average 120 lbs. per square inch.

NOTE.—The specimens 1 and 2 were made by a different operator to the remainder. The specimen 6 was beyond the capacity of the steel shank attached to the disc, which twisted off.

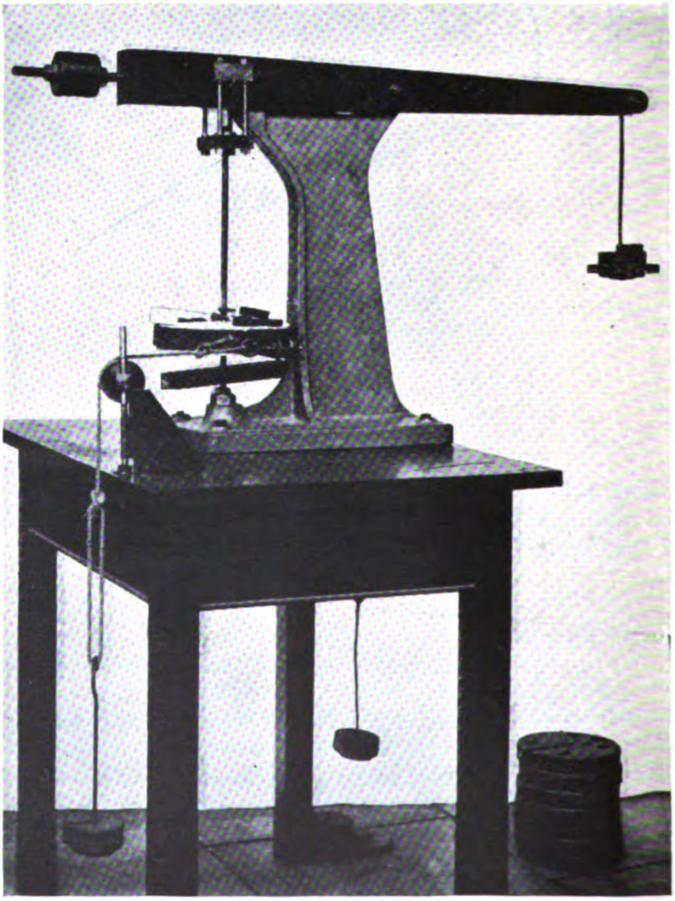


Fig. 4.

These two series of experiments were carried out to determine the magnitude of the pure adhesion or "stickiness" between the concrete and the steel for use in the third series, but the variation produced by the conditions of casting make it impossible to apply the figures as originally intended.

In the third series of tests, discs of concrete 10 in. in diameter and 2 in. thick were cast co-axially on ½-in. diameter mild steel bars, the casting position being with the axes of the bars vertical. The surfaces of the bars in contact with the concrete were turned and smoothed. At the appropriate period the specimens were placed in a specially-constructed testing machine with the bars in tension, and pure couples were applied to twist the concrete discs relative to the bars. A photograph of the arrangement is shown in *Fig.* 4. The tensile stress in the bars was different in each specimen, varying from 0 to 16,000 lbs. per sq. in. Two tests were made at each stress. An indicator was arranged between the discs and the bars to show the relative rotation, and was sensitive to about 0·01 deg. The breakdown had the same characteristics throughout the series. No relative movement was shown until the couple had increased up to the critical point, when adhesion broke down, and this was generally accompanied by a slip of about 0·05 deg. Thereafter, with each uniform increment in the couple, a more or less sudden and uniform increment in the relative movement took place, the indicator remaining quite steady after the slip had occurred until such time as the couple had increased sufficiently to overcome completely the frictional resistance, when the rotation proceeded jerkily without any further increase in the couple. The results are as under, each figure being the mean of two experiments :—

TABLE III

Tensile Stress in Bar. Lbs. per sq. inch	0	1,000	2,000	3,000	4,000	5,000
Initial Tangential Stress. Lbs. per sq. inch	348	337	223	203	237	250
Final Tangential Stress. Lbs. per sq. inch	449	745	530	550	459	621
Tensile Stress in Bar. Lbs. per sq. inch	6,000	7,000	8,000	9,000	10,000	11,000
Initial Tangential Stress. Lbs. per sq. inch	273	177	272	180	262	234
Final Tangential Stress. Lbs. per sq. inch	391	440	329	398	361	411
Tensile Stress in Bar. Lbs. per sq. inch	12,000	13,000	14,000	15,000	16,000	—
Initial Tangential Stress. Lbs. per sq. inch	325	182	201	172	196	—
Final Tangential Stress. Lbs. per sq. inch	464	416	301	402	416	—

These figures are shown plotted in the curves of *Fig.* 5. There is the usual type of variation which seems to occur in most ultimate tests on concrete, and only the general trend of the curves is possible. The lower line, showing the first slip stress, or the breakdown of the adhesion, looks as though it may be straight, the stress declining in intensity as the tensile stress in the steel increases. The decline is from about 300 lbs. per sq. in. with no stress in the steel to about 160 lbs. per sq. in. when the steel is stressed to 16,000 lbs. per sq. in. This is the

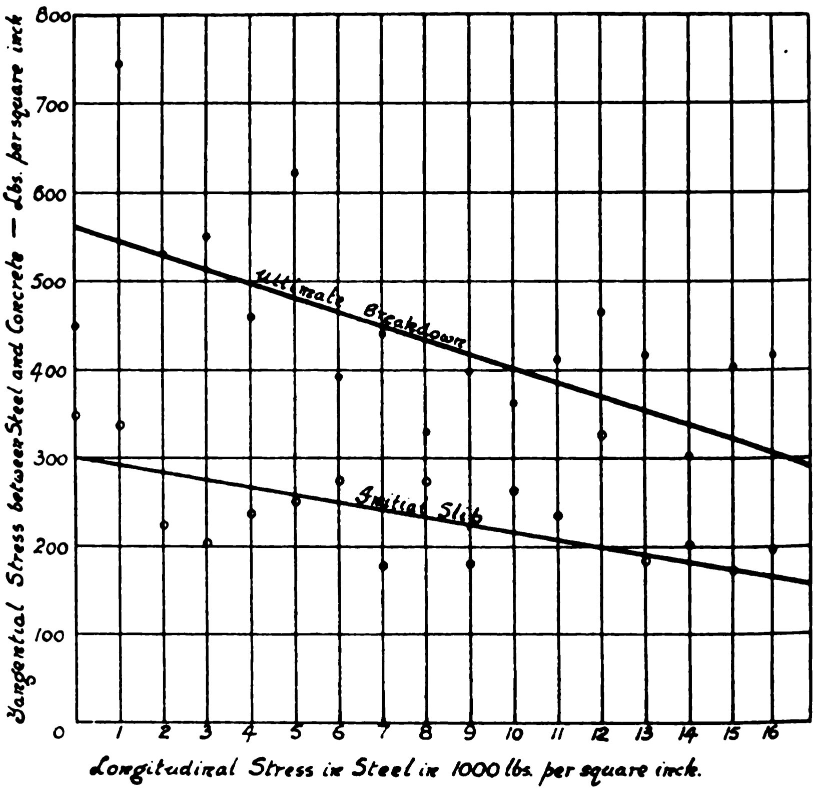


Fig. 5.

type of result that might be anticipated, as the diametral strain in the steel due to the longitudinal stress, and also the actual extension of the steel, may be expected to draw it slightly away from the concrete.

Treating the concrete disc as a thick cylinder, and making the usual assumptions, it may be shown that a relationship such as given below should exist.

Tangential stress necessary to cause relative rotation against frictional resistance (f)

$$= \mu . \left\{ p - \frac{\rho_s}{1 + m\rho_c - \rho_s + m\frac{R-r}{R+r}} . t \right\}$$

Where :—

R and r are the external and internal radii of the disc respectively (5 inches and 0·25 inch)

μ is the coefficient of friction between the concrete and steel (0·5)

p is the initial radial compressive stress in the concrete at the surface of contact with the steel

t is the longitudinal tensile stress in the steel

ϱ_s and ϱ_c are Poisson's Ratios for steel and concrete respectively. (0·3 in each case)

m is the ratio of the elastic moduli of steel to concrete (about 7 with this class of concrete)

Whence

$$f = 0{\cdot}5\left\{p - \frac{0{\cdot}3}{1 + 7\cdot 3 - 0{\cdot}3 + 7\cdot\dfrac{5 - 0{\cdot}25}{5 - 0{\cdot}25}}.t\right\}$$

$$= \frac{p}{2} - 0{\cdot}016.t.$$

This is, of course, a straight line with a declining slope of 0·016. The upper line on the curve is drawn at this slope to lie as evenly as possible amongst the experimental points. It indicates that the initial radial compressive stress between the steel and concrete is of the order of 1,120 lbs. per sq. in. The thick cylinder theory thus shows a hoop tensile stress in the same region in the concrete of about the same intensity. That there is a considerable hoop tension present is shown by the fact that a number of the discs were found to have radial tension cracks in them in the central region. It would appear, however, that this very high value of the tensile stress should have made cracks apparent in all the specimens, in which case the whole theory breaks down, as the material would no longer be elastic, but this was not the case. As some of the specimens were definitely cracked the fact may account for the variable character of the figures. By producing the line further to meet the steel stress axis it is found that the tangenitial stress necessary to produce relative rotation would be reduced to zero when the tensile stress in the steel is of the order of 35,000 lbs. per sq. in., which is in the vicinity of the elastic limit stress and is thus in reasonable agreement with the ordinary pull-out tests for long bars of small diameter.

The concrete is of good quality and the steel smooth, but even so the initial slip stress is getting perilously near to the usually accepted safe working stress of 100 lbs. per sq. in. It may be that with the ordinary commercial concrete the results would be even lower when the steel is at its full working stress, and it would appear that some form of deformed bar is almost a necessity to safeguard against this kind of failure.

The experiments described were carried out in the Engineering Laboratories of Cambridge University.

Constitution of Cement Clinker and of Blast-Furnace Slag.

WHEN examined under X-rays crystalline substances give rise to optical interference, whereas amorphous bodies only cause a black tinge. This fact has been made use of by F. Wever in the examination of cement clinker and blast-furnace slag, and the results of his work are given in a recent number of "Zement."

The two slags examined did not show any trace of interference, and are therefore amorphous bodies. The various cement clinkers examined were arranged according to their composition, those with the least slag giving the most interference. Portland cement and aluminous cement, of course, gave very clear interference bands.—W. S. G.

Book Reviews.

Cement, Concrete and Bricks. By Alfred B. Searle. Second Edition.
(London: Constable & Co., Ltd. Price 24s. net., pp. 441.)

In these days when the application of science to building materials is being heralded it is useful to have a text-book which deals in a scientific manner with the three most important non-metallic constructional materials, and this volume serves that purpose. The chemistry of cement is thoroughly discussed, and summaries are given of the modern research work and opinions upon the chemical constitution of cement and the precise changes which occur when cement sets and hardens. Although the manufacture of cement seems comparatively simple the author gives a list of no less than eight chemical compounds of lime, silica, and alumina believed to exist in a normal Portland cement in addition to the minor quantities of iron, magnesia, and sulphur compounds also present.

The chapter dealing with the manufacture of cement is disappointing because the methods described are, generally speaking, obsolete. The statement that "it is customary to break up lumps of chalk more than three inches in diameter with small picks or hammers" before entering the washmill might have been true last century, but is a travesty of modern conditions when ten tons of chalk at a time in pieces up to 100 lbs. in weight are tipped into the washing plant. An illustration described as a "cement plant with rotary kiln" is in reality a tube mill!

The section on concrete is to be welcomed for its sound teaching on the choice of concrete aggregates and methods of concrete production. On the subject of waterproofing concrete the author points out that the water-repellent materials of which many of the proprietary articles are formed defeat their ends because of the difficulty of mixing them with water. The first principles of reinforced concrete are clearly explained, and various types of reinforcement described. Proper reference is made to the work of Professor Duff Abrams in connection with the water-cement ratio, and the use of pozzuolana or trass—strangely neglected in this country—is advocated as a means of rendering concrete denser and more resistant to the action of sea water.

The section on bricks deals with the raw materials, methods of manufacture, and the characteristics of the various types of bricks, and should be useful to those desiring to gain knowledge on the qualities of bricks.

Although some of the book is necessarily in highly technical language, there is much that will appeal to the general reader who is interested in constructional materials.

Portland Cement Research. By R. H. Bogue.
(Paper No. 4 of the Portland Cement Association Fellowship (U.S.A.), pp. 12.)

Co-operative research is being conducted in the United States by the Government Bureau of Standards and the Portland Cement Association, the latter body being composed of cement manufacturers. This pamphlet describes the work being done by a staff of chemists, physicists, and petrographers, the prime objects being to discover the precise chemical compounds which exist in cement and the changes which take place when cement sets. The scheme of research promises to be exhaustive, and definite results appear to be assured if the work can be carried to its conclusion.

An Elementary Treatise on Statically Indeterminate Stresses. By John Ira Parcel and George A. Maney, of the University of Minnesota, U.S.A.
London: Chapman & Hall, Ltd. Price 25s. net.

The title must not mislead the reader into thinking that this book is elementary except in its academic significance. The problems of secondary stresses and indeterminate structures are fundamentally involved, and probably will always remain so. This treatise therefore assumes the reader is thoroughly conversant with the first principles of the theory of structures, and then proceeds to outline and develop the methods of analysing statically indeterminate structures and computing their stresses. While written primarily as a classroom text-book, it is hoped by the authors that the book will prove useful to engineers wishing to work up the subject by independent study. There is little doubt that this hope will be fully justified.

Briefly stated, this work co-ordinates

and brings under one cover the older principles together with the results of recent researches and advances in their methods of application in the refinement of stress calculations that are of use to the structural engineer. Needless to add, from these authors, it is an extremely thorough and able work of high standing in which the requirements of practice are not ignored. In its survey it embraces structural steelwork and reinforced concrete, and presents many numerical examples illustrating the methods described.

The text is divided into chapters and sections convenient for reference purposes, and deals with the methods of Least Work, Maxwell-Mohr, Moment Areas, Elastic Weights, Williot Displacement Diagrams, Slope-Deflection, Influence Lines, etc., and their application to frames of all types, arches, etc.

The concluding chapter—a general discussion and historical review—forms most interesting reading and indicates the authors' wide understanding of the subject matter in relation to practical utility. Finally, a comprehensive bibliography is appended citing works up to 1925, with brief comments on their contents. No reference, however, is made in this book to the monographs or publications of recent British investigators, such as R. V. Southwell, H. M. Martin, and Professors Lamb and Pippard, mention of whose works would benefit the list and render the book still more useful to British students.—L. T.

Whitaker's Almanack, 1927.
(Complete edition, 6*s.*; abridged edition, 3*s.*)

THIS mine of information on practically every conceivable topic to which an everyday reference might be required is now published in two forms, the abridgment being a resumé of the whole of the contents of the complete edition. The complete edition is too well known and valued to need description. In the abridged edition the compression of sections formerly given at length has made possible the inclusion for the first time of many subjects of general interest hitherto reserved for the larger book. Among these new sections will be found an alphabetical series of 57 articles entitled "Questions of the Day," articles on "Science and Invention," and many other features. Some of the usual features have been retained in their entirety, among them being the "Parliamentary Summary," "Events of the Year," and similar articles, while a "Table of Abbreviations" has been included, and many statistical and other tables have been added to afford information on topics of general interest.

Collins' Engineers' Diary.
(London: William Collins, Sons & Co., Ltd. Prices from 2*s.* to 7*s.* 6*d.*, according to binding.)

THIS, the latest addition to the engineers' pocket books and diaries, contains a wealth of information of everyday use to engineers, although data on building construction is meagre. On steel sections, motive power, electricity, hydraulics, gas engineering, power transmission, etc., however, there are comprehensive sections. The handbook section occupies 128 pp., followed by a diary (one week per opening), and the usual memoranda pages. Measuring 5½ in. by 3½ in., it is a useful size for the pocket and the excellence of the binding is an assurance that it will stand hard wear and constant use.

Catalogue of Technical Books.—The 1925 supplement of the Catalogue of British Scientific and Technical Books issued by the British Science Guild (6 John Street, London, W.C.2) is now ready.

Reinforced Concrete in 1926.—Messrs. Mouchel & Partners, Ltd., inform us that they were responsible for the reinforced concrete design of the following structures illustrated in our January number: Super-generating station at Birmingham; engine sheds at Exmouth Junction; Coed Madoc Bridge, Carnarvonshire; Penn's Lane Bridge, Sutton Coldfield; road retaining wall at Tyddyn Badyn, Carnarvonshire.

Questions and Answers relating to Reinforced Concrete.

***Readers are cordially invited to send in questions relating to concrete. These questions will be replied to by an expert, and, as far as possible, answered at once direct and subsequently published where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.*—Ed.**

Design of Water Tower.

Question.—I should be glad if you would give me the following information with reference to the design of a water tower by Dr. Faber in *Concrete and Constructional Engineering* for February, 1924.

I wish to calculate the foundations of the tower—say isolated footings under each column. According to author's figures :—

(*a*) *p*·71 Load per pillar (weight of tower and water) . .	86,750 lbs.
(*b*) *p*·73 Load or pressure per pillar due to wind effect No. 1 = $\frac{24,600}{2}$ = 12,300 lbs.	12,300 lbs.
(*c*) Load or pressure per pillar due to wind effect No. 2 .	?
Total load or pressure acting on base of one pillar .	lbs

In resolving $R(a + b + c)$, the total force acting through the column, I obtain the component N acting vertically (or normal pressure) from which it is easier to obtain the dimension and reinforcement for slab (footing). Would you show me how to calculate this additional pressure (*c*) on the pillar due to wind effect No. 2 (racking) please ?

Cairo. H. H.

Answer.—The secondary effect of wind pressure is to produce bending moments in the pillars and in their foundations. This cannot be expressed by an additional load per pillar. There is additional stress in the pillar due to the bending, but no additional load on it other than what you have already calculated under item (*b*). Exactly the same remarks apply to the base.—O. F.

Highway Bridges.

Question.—In his interesting paper on Beam and Slab Concrete Highway Bridges published in "Concrete and Constructional Engineering" for May last, Sir E. Owen Williams does not make it quite clear what assumptions he made in calculating the correct thickness for the slab. The stresses in the slab depend largely on the relative deflections of the longitudinal beams determined by the relative moments of inertia of beam and slab. I presume the slab has been calculated as a continuous beam over fixed supports, and should be glad to know if this is so.—J. Halero Johnston.

Answer.—Sir Owen Williams replies as follows : In my paper on "Beam and Slab Concrete Highway Bridges," the slabs are calculated neglecting the deflection of the beam but not assuming fixation of the slab over the supports other than due to continuity. Bending moments in slabs are first of all a maximum for conditions of partial loading of the structure, i.e. when the beams are not fully loaded, and therefore not fully deflected. Further, any assistance that the torsional resistance of the beam may give is neglected.

Calcium Sulphate in Cements.

It has been known for a considerable time that calcium sulphate is a useful agent for retarding the set of cements and that, of the many forms under which this salt occurs, the ordinary plaster of Paris used in building is the most powerful and most reliable in action. The employment of ordinary hydrated gypsum necessitates the use of an increased amount of water when the concrete is being mixed, with a consequent lowering of the compressive strength of the concrete. In some cases this particular variety of calcium sulphate has not had any retarding effect. Anhydrous calcium sulphate—the natural *anhydrite*—added by itself to the clinker produces rather uncertain results, according to an article in "Zement." Additional gauging water was also required.—W. S. G.

Concrete in Mines.

NEW METHOD OF GALLERY LINING.

A NEW method of lining mine galleries, linings, and shafts has been introduced into this country by the British Schaeffer Co., Ltd., of 32 Victoria Street, Westminster, S.W.1. The system, the invention of Mr. H. Schaeffer, in its latest form is something midway between a rigid construction of reinforced concrete and a very elastic one of concrete blocks without reinforcement.

The system is based on the theory that before the creation of a hollow space in the shape of a mine gallery, the mass of rock—regarded in cross section—is in a state of

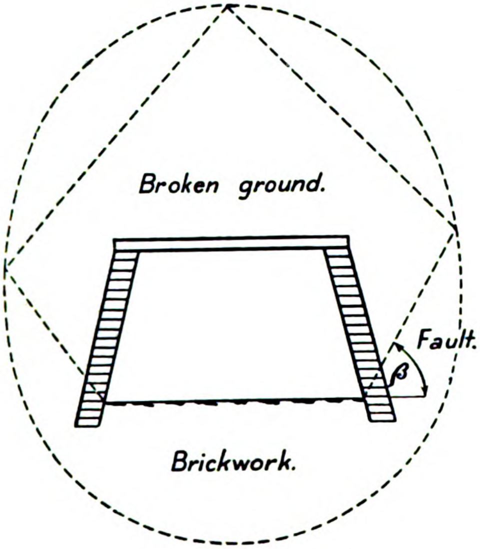


Fig. 1.

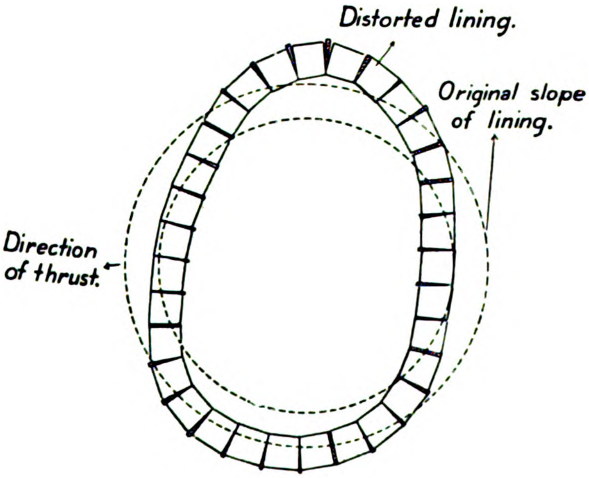
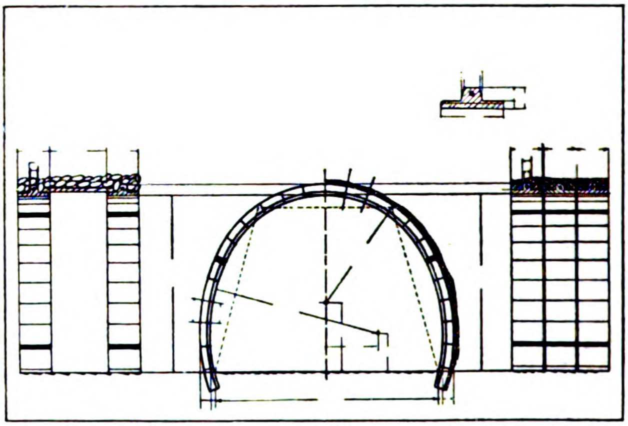


Fig. 2.

equilibrium. The effect of disturbing this equilibrium differs; in an unfissured and solid rocky mass it is almost nil, and it is greatest when the rock is soft and broken up by mining. The more friable the mass, the sooner will pressure be set up. At the very least, a quantity of stone, disturbed by the effect of continual repairs to the supports and the loosening of the joints in the strata of a faulty place, weighs down heavily on the support. The destruction of the support or lining is in almost every instance the result of heavy pressure.

The following must, therefore, be regarded as the essentials of a really durable support: The thickness (sectional dimensions) of the slabs must be such as will carry the load of the loosened mass of rock without question. Further, it must be flexible enough (flexible in its capacity to alter its shape without diminution of



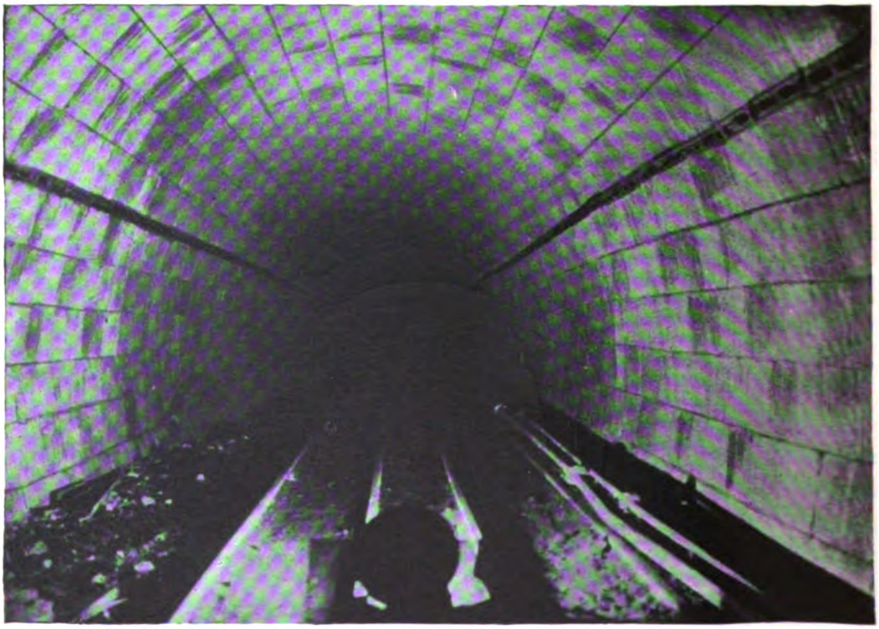


Fig. 3.

its transverse sectional area) to accommodate itself to the natural direction of the pressure in the surrounding ground until the loosened mass has become consolidated into a self-supporting roof.

These requirements are claimed to be met by the new system with a minimum of material and therefore at a minimum of expense. The supporting tube is divided into a series of independent rings, and upon the principle that the greater the movement in the ground the smaller must be the rings. Each ring consists of concrete slabs laid against each other without mortar. To render an alteration in the shape possible, compression courses are inserted at statically important points. It is a speciality of the system that these alterations of shape cannot exceed certain limits. The slabs are made with holes near the outer circumference of the lining, and are reinforced during erection by a steel and concrete core.

By this means dangerous pressure upon the internal edges is avoided without interfering with the working of the compression courses. If there were no external steel reinforcement, or if it were not suitably applied, distortions similar to *Fig.* 2 are possible.

With certain exceptions, "T" slabs are almost always employed; in comparison with a solid slab it possesses the great advantage that with an equal transverse sectional area it gives a greater strength of lining, or with a smaller sectional area an equal strength, greater solidity and a lower cost is attained and a greater power of resistance to pressure. The following illustration explains this.

Square Slabs.—Proportions—1 cement to 6 aggregate; 1 metre long = cost 165*s*.

Compression Strength: 30 cm. by 40 cm. = 1200 sq. cm. at 175 kg. per sq. cm. = 210 tons per slab.

"*T*" *Slabs.*—Proportions—1 cement to 4 of aggregate; 1 metre long = cost 124*s*.

Compression Strength: 795 sq. cm. at 270 kg. per sq. cm. = 215 tons per slab.

The slabs are made under a patented method with pneumatic stamps, by which it is possible, at a minimum cost, to produce slabs possessing high compressive strength, exact shape, and smooth surfaces. The blocks can be lifted by one man and transported in any tram wagon. The forms are erected on the spot. No special arrangements are required, so that erection can be done without interfering with the normal working of a mine.

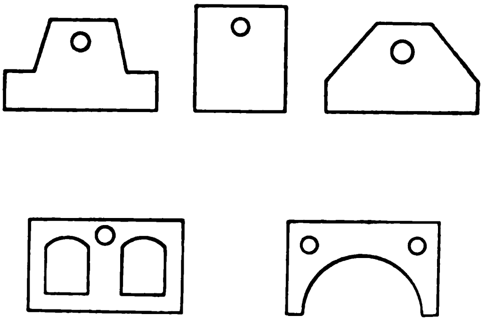


Fig. 4.—Types of Slabs.

The lining is supplied in three modifications:

(1) As a light gallery lining, e.g. in airways, engine rooms, etc.

(2) For medium pressures, e.g. in the faulty places.

(3) For the heaviest pressures resulting from the working out of seams or otherwise.

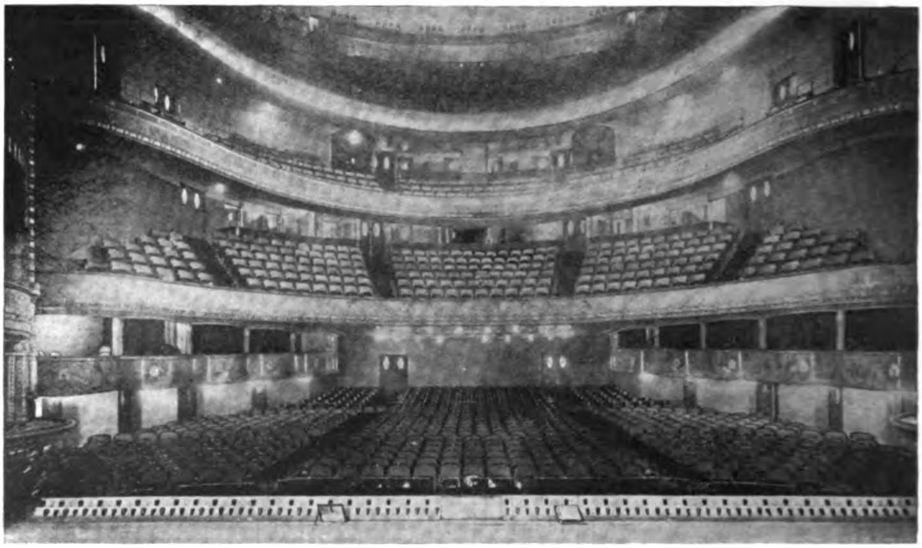
The determination of the dimensions is guided by the general principle that the support must be the lightest which is necessary. A fixed standard has hitherto been found unattainable. Based on a wide experience, it is meantime possible to find the most economical method for each case. Generally speaking it may be taken as a guiding principle that the softer and more rotten the ground the more elastic and strong the lining must be. If the lining be built before the pressure develops a lighter support may be chosen than if the gallery has already been repaired many times. To estimate the pressure properly it is essential to possess intimate knowledge of local conditions and the peculiarities of the ground.

We illustrate one of the many instances abroad in which this system has been employed (*Fig.* 3). This is a locomotive siding and an inset that required lining to prevent the collapse of the roof and walls. Brickwork had previously been employed. In brick the cost of a wall 16 in. thick was 182*s*. per lineal yard, while in the Schaeffer system the cost was only 41*s*. 6*d*. per lineal yard.

Reconstruction of Marseilles Opera House.

THE Grand Theatre (or Municipal Opera House) of Marseilles has now been reconstructed after the fire of 1919 in which it was practically destroyed. It was decided to preserve as far as possible the original stone façades, and this has been done, but the interior has been entirely reconstructed in reinforced concrete.

The interior arrangement is shown on the drawings on pp. 167 to 169. The principal supports and the galleries are four octagonal columns with 16-in. sides, each of which carries about 600 tons. The main beam between columns *a* and *b* (*Fig.* 1) is 5 ft. deep by 1 ft. 2 in. wide. The beam carrying the top gallery is coupled with the general framing of the upper part of the building, and is also tied at *A*, *B*, and *C*, *Fig.* 2. At *D* part of the load is carried by tie-beams suspended from beam *M*, *N*. The architects are MM. Castel, Ehrard, and Raymond, and the contractors MM. Jalhut and Ricord.



Marseilles Opera House: Interior View.

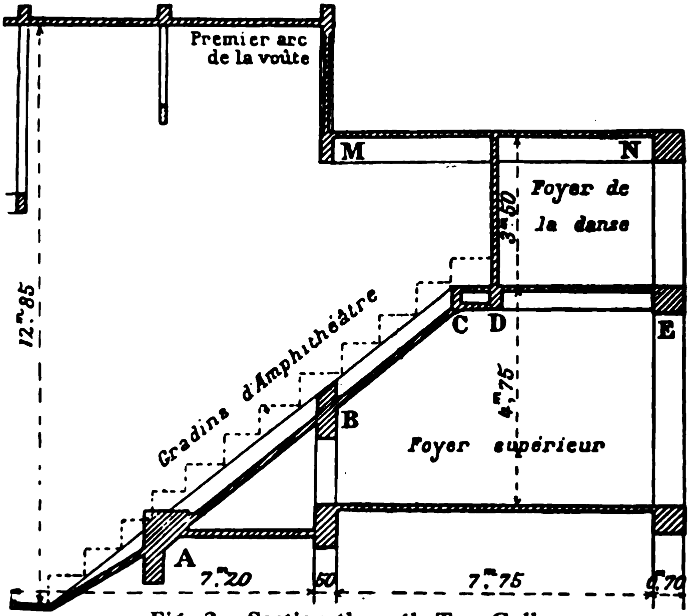
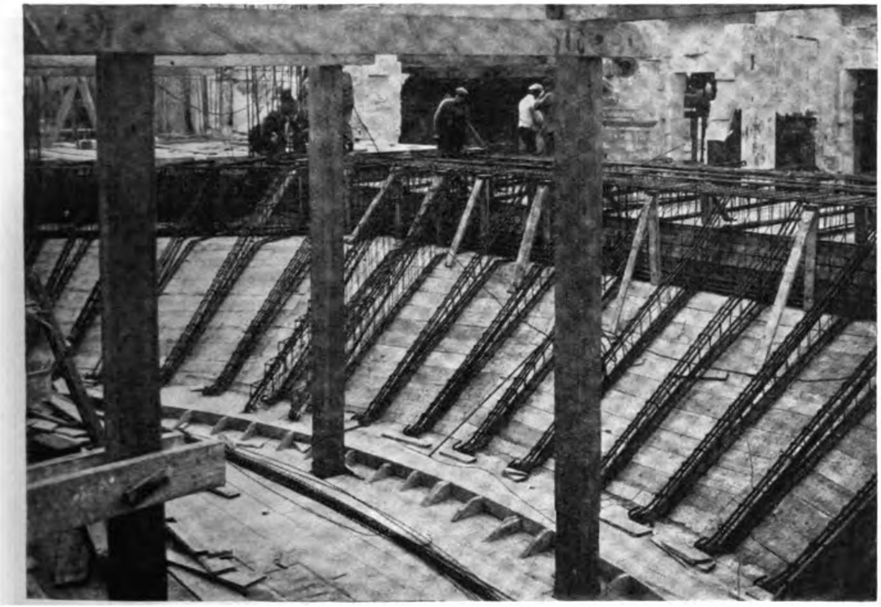
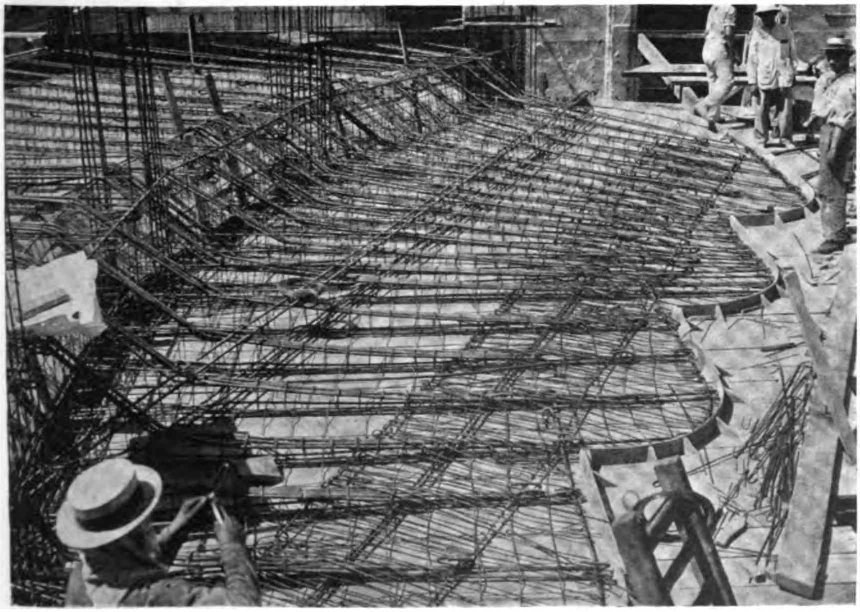


Fig. 2.—Section through Top Gallery.

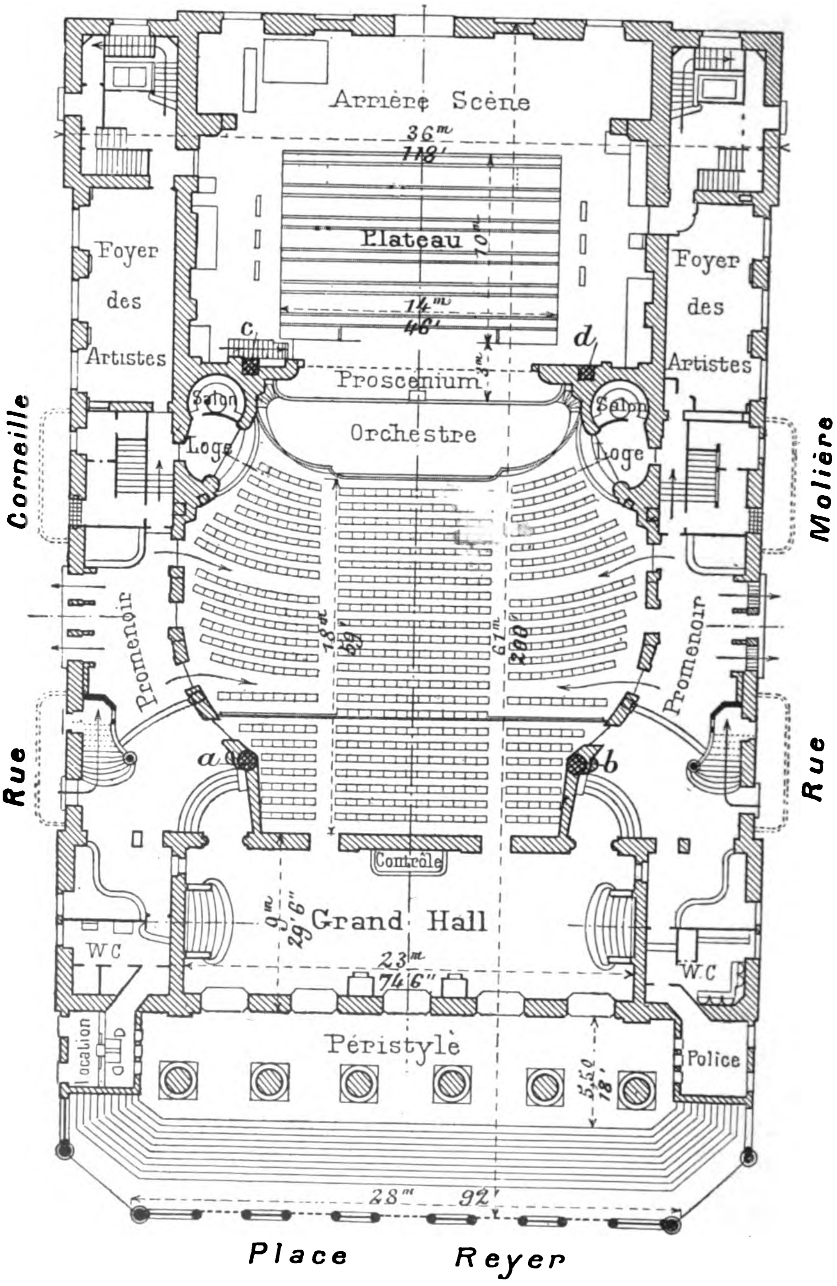


Gallery during Construction.

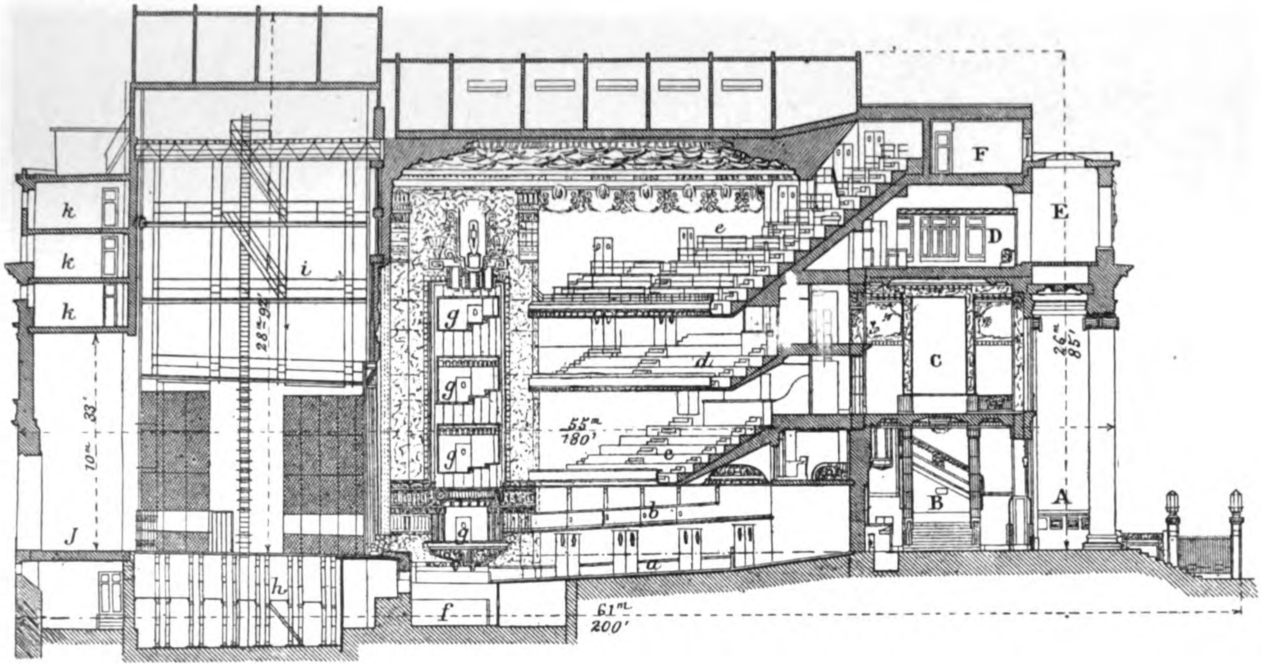


Reinforcement under Boxes.

Reconstruction of Marseilles Opera House. (*See p.* 166.)



Reconstruction of Marseilles Opera House : Plan (Fig. 1).
(*See p.* 166.)



Reconstruction of Marseilles Opera House: Section. (*See p.* 166.)

Flat Slab Design.*

THE subject of this volume is the design of flat slabs reinforced in more than one direction. The author, Dr. Lewe, is a recognised authority in Germany on the calculation of stresses in slabs of the mushroom type. This type of construction has only recently been introduced into Germany, where it has been taken up eagerly by engineers for warehouse and tank work. An abstract of the German regulations for flat slabs appeared recently in "Concrete and Constructional Engineering."

Beginning with the older treatments of flat slabs due to Grashof and Eddy, Dr. Lewe points out their deficiencies from the point of view of theory. The well-known method of dividing the panel width into bands is then described and is followed by an account of the new American regulations for two-way and four-way slabs. A comparison between these and the German regulations is then made. The latter rules specify the design moments at top and bottom of columns in terms of the column stiffness and load.

A large portion of the book is devoted to an exact solution of slab problems based on the use of Fourier's expansions. This method, originally due to Navier, may be found in Love's "Elasticity." From the point of view of the designing engineer the treatment is laborious, and it requires more than an average mathematical training to be able to follow the reasoning with ease. Dr. Lewe provides a large number of tables which will simplify the work of calculating bending moments in the various arrangements of slabs with which he deals.

Of particular interest is the treatment of rectangular rafts on elastic foundations. Present-day Continental practice in the design of foundations tends towards the use of a "ground-compression" coefficient, i.e. a number expressing the amount of sinking of the ground under a standard loading, to indicate the nature of the subsoil instead of the older method of describing the ground as capable of resisting so many tons per square foot of pressure. The tabular matter in the book is accompanied by explanatory examples.

It is difficult to review a book of this nature, which is an endeavour to make theory fit a method of construction which has been used for many years and designed on a far from scientific basis. It is even doubtful whether a theory is required until we are able to say that Poisson's ratio has a fixed value for any definite mix of concrete. The ratio must enter any theoretical investigation of flat slabs, and up to the present its value is very uncertain. Some authorities give impossible values in their tables.

The last thirty pages of this book are devoted to descriptions of flat-slab work carried out by German engineers. These include warehouses, tank-floors, cooling-tower foundation, grain stores, etc. The illustrations are excellent.—W. S. G.

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* "Pilzdecken und andere trägerlose Eisenbetonplatten." By Dr. Lewe (Berlin: Wilhelm Ernst & Son, Price 12 R.M.)

"Contex."—A correspondent informs us that he recently purchased two gallons of "Contex," a material for surface treating concrete described in the November number of this journal, at a price of £1 6*s.* a gallon. When the material reached the dock, however, he was informed that it had been analysed by the Customs and was found to contain a considerable percentage of spirit, with the result that it was dutiable to the extent of £3 18*s.* 5*d.*

Stothert & Pitt, Ltd.—Mr. James Railton, of Messrs. Topham, Jones & Railton, public works contractors, has joined the Board of Messrs. Stothert & Pitt, Ltd., Bath.

Estimating Quantities for Concrete.

A RECENT bulletin of the National Sand and Gravel Association, of Washington, contains a description of a method of estimating quantities of materials for concrete advocated by Mr. Stanton Walker, Director of the Engineering and Research Division of the Association. In dealing with methods in use, it is stated that since concrete became an important structural material there has been a demand for an accurate method of estimating the quantities of materials which it requires for different proportions. Various formulæ have been proposed and a number of different tables have been computed to assist the engineer in estimating the quantities of cement and aggregate for concrete. Many of such formulæ and tables lack flexibility or accuracy, or both, due to the efforts made to attain simplicity. The formulæ for the most part are based on the voids or density of the aggregate, but do not take into account the important part played by the quantity of mixing water in determining the volume of concrete. For example, a comparatively fine aggregate with high voids may produce a greater volume of concrete for the same amount of cement than a coarser aggregate with low voids, due to the fact that more mixing water is required for the finer aggregate than for the coarser material. A method for the estimation of quantities of materials based on the density of the aggregate, which takes into account the quantity of mixing water, is fundamentally correct.

The method described is based on the fact that the volume of concrete is equal to the volume of the solids in the aggregate plus the volume of cement paste, so long as there is a negligible quantity of unfilled voids or air. The method described eliminates the mortar-voids test and seems to give equally accurate results.

The following formula is derived from which the quantity of cement per cubic yard of concrete may be calculated if the concrete is plastic and workable and the approximate water-ratio, the weights of aggregates used with each 94 lb. cu. ft. of cement, and the approximate specific gravities of the aggregates are known :

Bbls. of cement per cu. yd. of concrete

$$= \frac{6{\cdot}75}{0{\cdot}5 + x + \dfrac{W_f}{62{\cdot}5\,S_f} + \dfrac{W_c}{62{\cdot}5\,S_c}} \qquad (1)$$

Where :

x = water-ratio ; ratio of volume of mixing water to volume of cement.

W_f = weight of fine aggregate in pounds used with one 94 lb. cu. ft. of cement.

W_c = weight of coarse aggregate in pounds used with one 94 lb. cu. ft. of cement.

S_f and S_c = apparent specific gravities of fine and coarse aggregates, respectively.

For aggregates of average specific gravity this equation can be reduced to the following simple form :

Bbls. of cement per cu. yd. of concrete

$$= \frac{6{\cdot}75}{0{\cdot}5 + x + \dfrac{(W_f + W_c)}{166{\cdot}6}} \quad . \quad (2)$$

The solution of Equation 2 is made easy by the chart in *Fig.* 1.

The method may be expressed algebraically as follows :

$$C = V_p + D_f + D_c \quad . \quad . \quad (3)$$

Where :

C = Volume of concrete.

V_p = Volume of cement paste.

D_f = Volume of solids (absolute volume) of fine aggregate.

D_c = Volume of solids (absolute volume) of coarse aggregate.

V_p, the volume of cement paste can be calculated with sufficient accuracy as follows :

$$V_p = V_c\,(0{\cdot}5 + x) \quad . \quad . \quad (4)$$

Where :

V_p = Volume of cement paste, in Eq. 3.

V_c = Volume of cement, assuming 1 cu. ft. to weigh 94 lb.

x = Water-ratio ; ratio of volume of mixing water to volume of cement, or cubic feet of water per 94 lb. cu. ft. of cement.

Equation 4 is based on the assumption that the volume of cement paste is equal to the absolute volume of cement (volume of solids) plus the volume of mixing water. For an average specific gravity of cement of about 3·12 the number of cubic feet of solids in 94 pounds of cement is $\frac{94}{62{\cdot}5 \times 3{\cdot}12} = 0{\cdot}48$. This value plus the volume of mixing water gives the volume of the paste with a fair degree of accuracy. The use of the factor 0·5 instead of 0·48 does not introduce an important error into the method.

The volume of solids in a given weight of aggregate may be calculated as follows:

$$D = \frac{W}{62{\cdot}5\,S} \quad . \quad . \quad . \quad (5)$$

Where :

D = Volume of solids in aggregate as in Eq. 1.

W = Weight of aggregate in pounds.

S = Apparent specific gravity of aggregate.

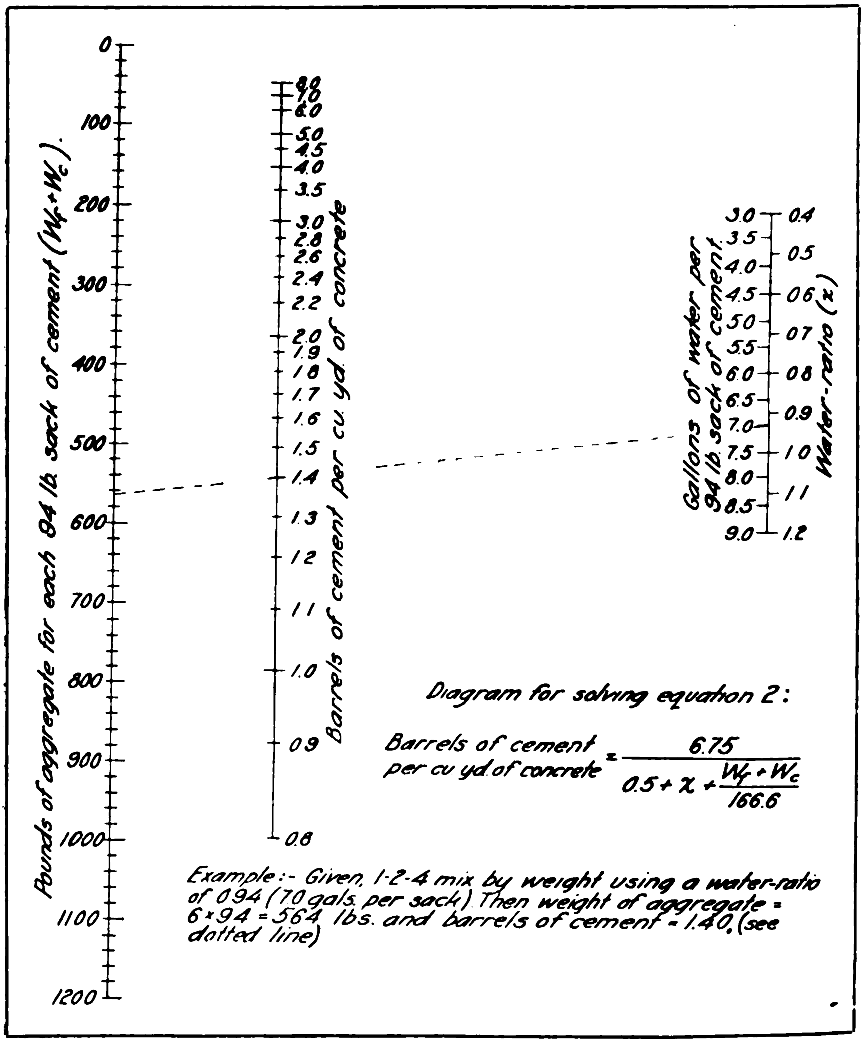

Diagram for solving equation 2:

$$\text{Barrels of cement per cu yd of concrete} = \frac{6.75}{0.5 + x + \frac{W_f + W_c}{166.6}}$$

Example:- Given, 1-2-4 mix by weight using a water-ratio of 0.94 (7.0 gals. per sack) Then weight of aggregate = 6 × 94 = 564 lbs. and barrels of cement = 1.40, (see dotted line)

Fig. 1.—Diagram for Estimating Quantity of Cement per Cubic Yard of Concrete.

(1 barrel = 376 lbs.)

Therefore Equation 3 may be written as follows for the volume of a batch of concrete made with 1 sack of cement :

$$C = 0{\cdot}5 + x + \frac{W_f}{62{\cdot}5\,S_f} + \frac{W_c}{62{\cdot}5\,S_c} \quad (6)$$

For aggregates having specific gravities ranging from 2·60 to 2·70, as most aggregates do have, the substitution of the factor 166·6 (or $1\frac{2}{3} \times 100$) for 62·5 S will not introduce an important error into the method.

Therefore substituting this constant, Equations 1 or 2 the weight or volume of fine and coarse aggregate would be found by multiplying the weight or volume of the cement by the number of weights or volumes of the aggregates.

As will be seen, the method gives results accurate within 2 or 3 per cent. so long as :

(1) The concrete is plastic and workable and all voids in the aggregate are filled with cement paste.

(2) No water is lost, as in the case of extremely wet mixtures.

Table 1.

COMPARISON OF ESTIMATED QUANTITIES WITH TABLES OF THE STRUCTURAL MATERIALS RESEARCH LABORATORY.

Mix by volume	*Size of aggregate*			*Water-ratio*	*Estimated unit weights lb. per cu ft.*		*Barrels of cement per cu. yd. of concrete*	
	Fine	*Coarse*			*Fine*	*Coarse*	*From Bull. 9*	*Calculated from Eq. 2*
1-2.3	0–No. 4	None		0.9	112	......	2.24	2.30
1-1.5-3.0	0–No. 8	No. 4–1	in.	0.9	108	106	1.56	1.57
1-2.1-2.8	0–No. 4	⅜–1	in.	0.9	112	106	1.51	1.47
1-1.7-3.4	0–No. 4	No. 4–1½	in.	0.9	112	112	1.44	1.40
1-2.3-4.2	0–No. 4	¾–3	in.	0.9	112	110	1.23	1.18
1-1.8	0–No. 4	None		0.8	112	....	2.71	2.69
1-1.1-2.5	0–No. 8	No. 4–1	in.	0.8	108	106	1.82	1.87
1-1.6-2.3	0–No. 4	⅜–1	in.	0.8	112	106	1.83	1.75
1-1.3-2.8	0–No. 4	No. 4–1½	in.	0.8	112	112	1.78	1.66
1-1.8-3.4	0–No. 4	¾–3	in.	0.8	112	110	1.49	1.42
1-1.4	0–No. 4	None		0.7	112	....	3.18	3.14
1-0.8-2.0	0–No. 8	No. 4–1	in.	0.7	108	106	2.27	2.26
1-1.1-1.9	0–No. 4	⅜–1	in.	0.7	112	106	2.26	2.14
1-0.9-2.2	0–No. 4	No. 4–1½	in.	0.7	112	112	2.15	2.06
1-1.3-2.6	0–No. 4	¾–3	in.	0.7	112	110	1.87	1.78
1-0.7	0–No. 4	None		0.56	112	....	4.36	4.41
1-0.4-1.1	0–No. 8	No. 4–1	in.	0.56	108	106	3.51	3.45
1-0.5-1.0	0–No. 4	⅜–1	in.	0.56	112	106	3.30	3.32
1-0.4-1.2	0–No. 4	No. 4–1½	in.	0.56	112	112	3.34	3.16
1-0.6-1.5	0–No. 4	¾–3	in.	0.56	112	110	2.90	2.76

(1 barrel = 376 lbs.)

Equation 6 may be re-written as follows :

$$C = 0{\cdot}5 + x + \frac{W_f + W_c}{166{\cdot}6} \quad . \quad (7)$$

Or expressed without symbols :

The volume of concrete produced by one 94 lbs. cubic foot of cement is equal to 0·5 plus the volume of mixing water in cubic feet, plus the result obtained by dividing the weight of the aggregate by 166·6.

Equations 1 and 2 come directly from dividing 6·75 (the number of " barrels " in a cubic yard) by Equations 6 and 7 respectively.

Having determined the quantity of cement per cubic yard of concrete from

(3) No important amount of air is entrained as in the case of very dry and lean mixtures and of mixtures of extremely fine aggregate.

Application of Method.

The following information is required to apply this method :

(1) Proportions of cement to aggregate, either by weight or by volume.

(2) The weight per cubic foot of aggregate as used on the job ; required only where proportions are expressed by volume.

(3) The approximate water-ratio.

For example, consider a 1 : 2 : 4 mix by volume. From knowledge of the aggregates to be used, assume that it is known that the sand weighs 85 lbs. per cu. ft. and the gravel 100 lbs. per cu. ft., and that, from knowledge of the consistency of concrete which is to be used, approximately 7 gallons of water, or 0·94 cu. ft. of water, will be used with each cubic foot of cement. In this mix, therefore, for each cubic foot of cement there is 170 lbs. of sand, 400 lbs. of gravel and 0·94 cu. ft. of water.

Then substituting in Equation 2, we have:

Barrels of cement per cu. yd. of concrete

$$= \frac{6{\cdot}75}{0{\cdot}5 + 94 + \dfrac{170 + 400}{166{\cdot}6}}$$

$$= \frac{6{\cdot}75}{4{\cdot}86} = 1{\cdot}39 \text{ bbls. of cement.}$$

Or the solution may be made by drawing a straight line in *Fig.* 1 from 470 lbs. on the scale at the left to 7 gallons on the scale at the right and reading the intersection on the scale in the centre.

From this the volume of sand required is $2 \times 1{\cdot}39 \times 4 = \frac{11{\cdot}1}{27} = 0{\cdot}41$ cu. yd. and the volume of gravel, $4 \times 4 \times 1{\cdot}39 = 22{\cdot}2$ cu. ft. $= \frac{22{\cdot}2}{27} = 0{\cdot}82$ cu. yd. of gravel.

Had the mixture been expressed in terms of weight the calculations would have been equally simple. Assume that it is desired to determine the quantities of materials per cubic yard of concrete for a 1 : 2 : 4 mix by weight for the same water-ratio as above. The weight of sand and gravel for each 94 lbs. cubic foot of cement would be as follows:

Sand: 2 × 94 = 188 lbs.
Gravel: 4 × 94 = 376 lbs.

Table 2.

COMPARISON OF ESTIMATED QUANTITIES WITH MEASURED QUANTITIES.

				Aggregate			*Barrels of cement per cu. yd. of concrete*	
Data from	*Mix by volume*	*Water-ratio*	*Relative consistency*	*Size*	*Fineness modulus*	*Unit weight lb. per cu. ft.*	*Calculated from measured yield*	*Calculated from Eq 2*
Bull. 4	1-7	1.12	1.10	0-1½ in.	5.75	128	0.95	0.95
"	1-4	0.80	1.10	"	"	"	1.57	1.54
"	1-2	0.58	1.10	"	"	"	2.68	2.58
"	1-7	1.28	1.25	"	"	"	0.95	0.94
"	1-4	0.90	1.25	"	"	"	1.55	1.50
"	1-2	0.66	1.25	"	"	"	2.58	2.51
"	1-4	1.09	1.10	0-No. 4	3.05	115	1.48	1.55
"	"	0.96	"	0-⅜ in.	4.00	119	1.55	1.56
"	"	0.86	"	0-¾ in.	5.00	126	1.55	1.54
Bull. 8	1-6	0.92	1.00	0-1½ in.	5.75	127	1.12	1.12
"	1-5	0.82	"	"	"	"	1.31	1.32
"	1-4	0.72	"	"	"	"	1.59	1.58
"	1-3	0.62	"	"	"	"	1.98	1.98
"	1-6	1.00	1.10	"	"	"	1.11	1.11
"	1-5	0.89	"	"	"	"	1.31	1.29
"	1-4	0.78	"	"	"	"	1.57	1.56
"	1-3	0.68	"	"	"	"	1.97	1.94
"	1-6	1.12	1.25	"	"	"	1.10	1.09
"	1-5	1.00	"	"	"	"	1.29	1.27
"	1-4	0.88	"	"	"	"	1.54	1.53
"	1-3	0.76	"	"	"	"	1.94	1.90
"	1-5	1.26	1.10	0-No. 4	3.15	112	1.25	1.32
"	"	1.10	"	0-⅜ in.	3.50	117	1.25	1.32
"	"	0.97	"	0-¾ in.	5.00	126	1.27	1.28
"	1-4	1.09	"	0-No. 4	3.15	112	1.50	1.58
"	"	0.95	"	0-⅜ in.	3.50	117	1.52	1.58
"	"	0.85	"	0-¾ in.	5.00	126	1.53	1.54

(1 barrel = 376 lbs.)

Then :

Barrels of cement per cu. yd. of concrete

$$= \frac{6{\cdot}75}{0{\cdot}5 + 0{\cdot}94 + \dfrac{188 + 376}{166{\cdot}6}}$$

$$= \frac{6{\cdot}75}{4{\cdot}83} = 1{\cdot}40 \text{ bbls. of cement.}$$

Or the solution may be made by means of *Fig.* 1 by drawing a straight line from 564 lbs. on the scale at the left to 7 gallons on the scale at the right and reading the intersection on the scale in the centre.

The quantity of aggregate in tons can be readily calculated as follows :

Weight of sand per cu. yd. of concrete $= 1{\cdot}40 \times 4 \times 94 \times 2 = 1{,}050$ lbs. $= 0{\cdot}52$ tons.

Gravel $= 1{\cdot}40 \times 4 \times 94 \times 4 = 2{,}100$ lbs. $= 1{\cdot}05$ tons.

In the above calculation " 4 " is the number of cubic feet in a barrel of cement and 94 lbs. is the weight of one cu. ft. of cement.

Comparisons with Measured Quantities.

Tables 1 to 4 show comparisons of quantities of cement calculated from Equation 2 with values based on measured quantities.

Table 3.

COMPARISON OF ESTIMATED VALUES WITH MEASURED VALUES.

Mix by weight	*Water-ratio*	*Barrels of cement per cu. yd. of concrete* *Calculated from data in Pearson's and Hitchcock's papers*	 *Calculated from Eq. 2*
1-3 -6	1.44	0.95	0.96
1-2½-5	1.20	1.12	1 14
1-2 -4	1.01	1.36	1.38
1-1½-3	0.79	1.74	1.76

(1 barrel = 376 lbs.)

Table 4.

COMPARISON OF ESTIMATED QUANTITIES WITH CALCULATED QUANTITIES.

Mix by volume	*Water ratio*	*Barrels of cement per cu. yd. of concrete* *Given by Talbot and Richart*	 *Calculated from Eq. 1*
1-1-2	0 44	2.41	2.44
	0.53	2.37	2.36
	0.64	2.33	2.28
1-1½-3	0 53	1.78	1 79
	0 64	1 75	1.74
	0 75	1.73	1.70
1-2-3	0.59	1.60	1.62
	0.72	1.57	1.57
	0.84	1.54	1.53
1-2-3½	0.60	1.49	1.51
	0.72	1.47	1.47
	0.85	1.45	1.43
1-2-4	0 61	1.41	1.41
	0.73	1 38	1.38
	0.86	1.36	1.35
1-3-5	0 79	1 07	1.09
	0 94	1.06	1.06
	1.11	1.04	1.04
1-3 6	0 81	0.98	0.99
	0.98	0.96	0.97
	1.14	0.95	0.95

(1 barrel = 376 lbs.)

Table 1, which perhaps shows the least favourable comparison of any of the data studied, is made up from Bulletin 9 of the Structural Materials Research Laboratory "Quantities of Materials for Concrete" by Abrams and Walker. In general the difference between the values given in the tables of Bulletin 9 and those calculated from Equation 1 do not differ more than about 0·07 of a barrel of cement. This small error might readily occur from a slight error in the values which were assumed for the unit weights of the aggregates or due to slight differences in "rounding off" decimals in Abrams' and Walker's original calculations of the proportions.

Table 2 shows a comparison between values calculated from Equation 2 and values calculated from measured "yields" reported in Bulletins 4 and 8 of the Structural Materials Research Laboratory. The two sets of values show a very close agreement, the average difference being less than 0·03 barrel.

Table 3 shows a similar comparison for data reported in a paper before the 1924 convention of the American Concrete Institute by Pearson and Hitchcock. In no case is the difference between the measured and calculated values more than 0·02 barrels of cement.

Table 4 shows a comparison between barrels of cement calculated from Equation 2 and by Talbot and Richart based on the "mortar-voids" test and the solids in the gravel. The data are from Table 8 of Bulletin 137 of the University of Illinois Engineering Experiment Station "The Strength of Concrete, Its Relation to the Cement, Aggregates and Water," by Arthur N. Talbot and Frank E. Richart. An examination of the table will show a remarkably close agreement in the two sets of values.

High Tensile Reinforcement.

MR. EWART S. ANDREWS, B.Sc.,AM.Inst. C.E., writes:

I do not differ from the main point which Mr. Burness makes in his letter published in your December number, that if the permissible stress in the steel is increased then for the same stress in the concrete the amount of concrete must also be increased, assuming, of course, that the compression stress in the concrete is up to its maximum value—which it seldom is in a slab or T-beam.

In my article in your November number I was not dealing with the relative cost of ordinary and high tensile reinforcement, but was endeavouring to show that, so far as I could find experimental evidence, the use of high tensile reinforcement resulted in greater strength for the same area of reinforcement or equal strength for less area of high tensile reinforcement compared with that of the ordinary reinforcement.

At the present time in this country the use of high tensile reinforcement is to a large extent prohibited except for small sizes up to $\frac{5}{16}$-inch diameter, and when regulations do not prohibit its use the stress is still restricted to the same as for ordinary reinforcement. Although I have not gone into the question of relative costs of the steel, I think Mr. Burness has allowed for too large an extra cost of medium carbon steel over mild steel. The cost will depend much on the demand, and this in turn will depend on the extent to which regulations allow it to be used. Approximately, if we increase the stress from 16,000 lbs. to 20,000 lbs. the weight of steel will be reduced by one-fifth and if the increase in cost per ton is more than one-fourth then the stronger steel will cost more. If it should prove more expensive to use the high tensile reinforcement, presumably it will not be used; but if there are no technical objections against a steel, economic considerations only should decide whether or not it is to be used.

Tank at Nine Elms.—On page 68 of our last number we described an illustration of a tank as "Filter Tanks at Walton." This should have read "Gas Purifier Tank at Nine Elms, for the Gas Light and Coke Company." The engineers and contractors for the work were Messrs. Christiani & Nielsen, of Victoria Street, Westminster, S.W.1.

DATA FOR PRICING REINFORCED CONCRETE.*

MATERIALS DELIVERED 4 MILES FROM CHARING CROSS.

			s.	d.
Best Washed Sand	per yard		16	0
Clean Shingle, ¾ in. mesh	,,		14	0
,, ,, ½ in. mesh	,,		15	6
Thames ballast	,,		10	6
Broken brick (¾ in.)	,,		11	6
Best British Portland Cement	per ton	58s. to	63	6
"Ferrocrete" Rapid-Hardening Portland Cement	delivered London 10s. per ton extra			
"Super-Cement"	per ton	88s. to	93	0
"Lightning" Brand Aluminous Cement	,,	100s. to	105	6
Ciment Fondu	works f.o.r.		95	0

Boarding for Shuttering—

		Sawn. s.	Sawn. d.	Wrot. s.	Wrot. d.
1 in.	per square	23	6	27	6
1¼ in.	,,	29	6	33	6
1½ in.	,,	35	6	41	0

Sawn Timber for Struts and Supports—

3 in. by 4 in.	from £22 per standard
3 in. by 6 in. and 3 in. by 7 in.	,, £20 ,, ,,

Mild Steel Rods for Reinforcement—

		s.	d.
⅝ in. to 2⅞ in. Rounds	per cwt.	10	6
7/16 in. to ½ in. Rounds	,,	10	9
⅜ in. Rounds	,,	11	0
¼ in. Rounds	,,	12	0

Breeze Slabs per yd. super: 2 in., 1/11; 2½ in., 2/4; 3 in., 2/9; 4 in., 3/6.

MATERIAL AND LABOUR, INCLUDING 10 PER CENT. PROFIT.

(Based on Contracts up to £2,000.)

Portland Cement Concrete well mixed in proportion 1 : 2 : 4—

				s.	d.
Do.	do.	in foundation	per foot cube	1	11
Do.	do.	in columns	,, ,,	2	1
Do.	do.	in beams	,, ,,	2	3
Do.	do.	in floor slabs 4 in. thick	per yard super	6	0
Do.	do.	in floor slabs 5 in. thick	,, ,,	7	6
Do.	do.	in floor slabs 6 in. thick	,, ,,	9	0
Do.	do.	in floor slabs 7 in. thick	,, ,,	10	6
Do	do.	in walls 6 in. thick	,, ,,	8	8

(Add for hoisting 3s. 6d. per yard cube above ground-floor level. Add for "Ferrocrete" 1s. 10d. per yard cube.)

Steel Reinforcement, including Cutting, Bending and putting into Position and securing with Stout Binding Wire—

		s.	d.
From ¼ in. to ⅜ in.	per cwt.	22	6
,, 7/16 in. to ½ in.	,,	21	6
,, ⅝ in. to 2⅞ in.	,,	20	6

EXTRA LABOUR TO BENDS in ¼-in. rods, ½d.; ⅜-in. rods, 1d.; ½-in. rods, 1¼d.; ⅝-in. rods, 1½d.; ¾-in. rods, 1¾d.; ⅞-in. rods, 2d.; 1-in. rods, 2¼d.; 1⅛-in. rods, 3d.; 1¼-in. rods, 3½d.; 1⅜-in. rcds, 4½d.; 1½-in. rcds. 6d. (per bend per cwt.).

EXTRA LABOUR TO HOOK BENDS: ¼ in., 1d.; ⅜ in., 2d.; ½ in., 2½d.; ⅝ in., 3d.; ¾ in., 3½d.; ⅞ in., 4d.; 1 in., 4½d.; 1⅛ in., 6d.; 1¼ in., 7d. (per bend per cwt.).

Shuttering—

		s.	d.
Shuttering and Supports for Concrete Walls (both sides measured)	per square	59	0
Centering to Soffits of Reinforced Concrete Floors and Strutting, average 10 ft. high	per square	55	0
Do. do. in small quantities	per ft. super	0	10
Shuttering and Supports to Stanchions for easy removal, average 18 in. by 18 in.	per ft. super	0	11½
Do. do. as last, in narrow widths	,, ,,	1	1½
Do. do. to sides and soffits of beams, average 9 in. by 12 in.	,, ,,	1	1½
Do. do. as last, in narrow widths	,, ,,	1	3½
Raking, cutting, and waste to shuttering	per ft. run	0	3
Labour, splay on ditto	,, ,,	0	2
Small angle fillets fixed to internal angles of shuttering to form chamfer	,, ,,	0	3

WAGES.—The rates of wages on which the above prices are based are:—Carpenters and joiners, 1/9½ per hour; Carpenters working on old shuttering, 1/10½; Labourers on building works, 1/4½; Men on mixers and hoists, 1/5½; Bar-benders, 1/5½.

[* This Data is specially compiled for *Concrete and Constructional Engineering*, and is strictly copyright.]

Prospective New Concrete Work.

BATH. — *Concrete Bridge.* — The City Council proposes to reconstruct in reinforced concrete the old city bridge.

BIDEFORD.—*Houses.*—The T.C. proposes to erect 32 houses on the Handy Cross Estate.

BINGLEY.—*Road.*—The U.D.C. proposes to spend £64,000 on the construction of a road.

BILLINGHAM.—*Houses.*—The U.D.C. has applied for sanction to borrow £94,842 for the erection of 222 houses.

BRISTOL.—*Houses.*—The T.C. is to build 86 houses at Rodney Road by direct labour.

BRISTOL. — *Roads.* — The T.C. has applied for sanction to borrow £12,450 for the construction of roads.

BRISTOL. — *Reservoir.* — The Bristol Waterworks Co. has applied for Parliamentary powers to construct a reservoir.

BROCKTON.—*Bridge.*—The Chirbury R.D.C. has instructed the Surveyor to prepare plans for the construction of a bridge over the Hampton Beach brook.

BUCKHAVEN.—*Sea Defence Works.*—The T.C. is considering a scheme for the construction of sea defence works at Ness Braes.

BURNLEY. — *Houses.* — The T.C. has been recommended to erect 88 houses on the Stoops Farm estate, at an estimated cost of £40,128.

CAMBUSKENNETH.—*Bridge.*—The C.C. and the Stirling T.C. are considering a scheme for the provision of a footbridge over the Forth at Cambuskenneth. The cost is estimated at £1,900.

CARLISLE.—*Houses.*—Application has been made for permission to erect 50 houses.

CARROMOSCAR.—*Reservoir.*—The Galway County Board of Health proposes to construct a reservoir at Carromoscar.

COULSDON AND PURLEY.—*Houses.*—The U.D.C. is preparing a scheme for the erection of 50 houses at Coulsdon.

DALWOOD.—*Bridge.*—The Axminster R.D.C is considering the question of building a bridge at Dalwood. The cost is estimated at £2,300.

DEVONPORT.—*Concrete Houses.*—The M.H and the Admiralty have agreed to a scheme to erect 174 concrete houses at Devonport. The cost is estimated at £100,000.

DEWSBURY.—*Reservoir.*—The T.C. proposes to spend £22,500 on the construction of a reservoir.

DOLLAR.—*Concrete Bridge.*—The Clackmannan C.C. proposes to spend £12,000 on the construction of a reinforced concrete bridge over the River Devon at Dollar.

DUDLEY.—*Houses.*—The T.C. proposes to erect 60 houses on the Watson's Green estate.

DUNDEE.—*Houses.*—The Housing Sub-Committee recommends the T.C. to erect 500 houses.

EASTBOURNE.—*Houses.*—The T.C. recommends that application be made for sanction to erect 100 houses.

EAST STIRLING.—*Houses.*—The Stirling C.C. is to build 200 houses.

EGHAM.—*Houses.*—The U.D.C. proposes to build 100 houses at an estimated cost of £47,443.

EXETER.—*Concrete Houses.*—The City Council has applied for sanction to borrow £56,000 for the erection of 108 concrete houses.

GRIMSBY.—*Houses.*—Application has been made for permission to erect 64 houses.

SITUATIONS VACANT.

REINFORCED Concrete Designers (two) required, with specialist training. Applications, stating age, experience and salary required, to Box No. 1265, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 20 Dartmouth Street, Westminster, S.W.1.

BUILDERS' Manager with special experience of reinforced concrete required, London district. Experience and salary expected to be stated, Box No. 1264, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 20 Dartmouth Street, S.W.1.

PATENT.

THE owner of British Patent No. 152,106, relating to Improvements in utilization of low grade carboniferous material in the manufacture of Portland Cement is desirous of entering into negotiations with one or more firms in Great Britain for the purpose of exploiting the above invention, either by the sale of the Patent rights or the grant of a licence or licences to work on royalty. Enquiries should be addressed to MESSRS. ABEL & IMRAY, 30 Southampton Buildings, London, W.C.2.

PATENT.

THE Proprietor of British Patent No. 220,329, relating to the Construction of Box Moulds for Concrete, is desirous of disposing of his rights in the above numbered patent, either by the sale thereof or by granting licences to manufacture under royalty, for the purpose of exploiting the same and ensuring its full development and practical working in this country. All communications to be addressed to :—H. A. GILL & Co., 51-52 Chancery Lane, London, W.C.2.

Glasgow. — *Concrete Houses.* — The Housing Committee recommends the Corporation to place a contract with Messrs. Henry Boot & Sons, Ltd., for the construction of 600 concrete houses.

Glastonbury.—*Houses.*—The T.C. has applied for sanction to erect 44 houses.

Groes. — *Bridge.* — The Colwyn Bay U.D.C. has prepared a scheme for the construction of a bridge at Groes.

Inverness.—*Houses.*—The T.C. proposes to erect 100 houses.

Kirkby Thore.—*Concrete Reservoir.*—The East Westmorland R.D.C. is to construct a concrete reservoir at Kirkby Thore.

Kirkcaldy. — *Houses.* — Application has been made for sanction to build 300 houses.

Lisburn (Ireland).—*Concrete Roads.*—The Urban Council has received permission to borrow £38,000 for the reconstruction in reinforced concrete of certain Class 1 roads.

Llechryd.—*Bridge.*—Plans have been prepared for the construction of a bridge at Llechryd. The cost is estimated at £20,000.

Loughborough.—*Houses.*—The T.C. has applied for permission to borrow £51,260 for the erection of 100 houses on the Shelthorpe Farm estate.

Lowestoft.—*Concrete Wall.*—The T.C. has applied for sanction to borrow £2,242 for the construction of a sheet-piled concrete wall in front of the Victoria bathing chalets.

Mansfield.—*Houses.*—The T.C. has applied for sanction to borrow £40,000 for housing purposes.

Middlesbrough. — *Houses.* — The Housing Committee recommends the Council to erect 30 houses by direct labour on the Marton Grove estate. The cost is estimated at £310 each.

Morten Fen.—*Bridge.*—The Bourne R.D.C. proposes to construct a bridge at Morten Fen to replace Elvidge's Bridge.

Neath.—*Road.*—A road is to be constructed through the Cattle Market.

Nenaddfach.—*Bridges.*—The Llandovery R.D.C. has prepared plans for the construction of bridges at Nenaddfach and Maes-issa.

Newcastle (Ireland).—*Bridge.*—The U.D.C. proposes to erect a bridge over the Tullybrannigan river.

Newry.—*Houses.*—A scheme for the erection of cottages is being considered by the R.D.C. The cost is estimated at £62,000.

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MOULD
OIL

GOES FARTHEST
FUNCTIONS BEST

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6 BROAD ST. PLACE, LONDON, E.C.2

Rackmill, Dollar.—*Concrete Bridge.*—The Clackmannan C.C. proposes to erect a reinforced concrete bridge over the River Devon at Rackmill, Dollar. The estimated cost is £12,000.

Ratmines. — *Concrete Road.* — The U.D.C. proposes to concrete Parnell Road.

Rotherham.—*Houses.*—The Corporation proposes to build 200 houses in the Meadow Bank district.

Rushden.—*Houses.*—The U.D.C. is considering a scheme for the erection of 32 houses in Irchester Road.

Sedgefield. — *Houses.* — The R.D.C. has applied for permission to erect 150 houses in the rural area.

Southwick.—*Houses.*—The Housing Committee recommends the U.D.C. to build 100 houses on the Marley Pots estate.

Taunton.—*Concrete Houses.*—The T.C. is to build 100 concrete houses, at an estimated cost of £40,000.

Walshaw.—*Houses.*—The Tottington U.D.C. is recommended to build 72 houses at Walshaw.

Warrington.—*Houses.*—The T.C proposes to erect 156 houses on the Bewsey estate and 10 houses on the Reynolds estate.

Winchester.—*Houses.*—The T.C. proposes to build 40 houses at Stanmore.

Wyke.—*Houses.*—The Bradford Corporation is to erect 350 houses on the Shirley Manor estate by direct labour. The cost is estimated at £177,000.

Tenders Accepted.

BALCOMBE (SUSSEX).—*Concrete Reservoir.*—The Mid-Sussex Joint Water Board has accepted the tender of Messrs. Mussellwhite & Sons, Basingstoke, at £3,986, for the construction of a reinforced concrete covered reservoir of about 517,000 gallons capacity. Other tenders submitted were: D. G. Somerville & Co., Ltd., £6,709; Monolithic & General Construction, Ltd., £6,546; Yorkshire Hennebique Contracting Co., Ltd., £6,406; Anglo-Danish Concrete Construction Co., Ltd., £5,663; West's Rotinoff Piling & Construction Co., Ltd., £5,634; W. Jones & Sons, Ltd., £5,624; Holloway Bros., Ltd., £5,589; G. E. Everitt & Sons, £5,584; Mears Bros., £5,554; Grays Ferro-Concrete Co., Ltd., £5,255; A. Streeter & Co., £5,131; L. J. Speight, Ltd., £5,110; Playfair Toole, Ltd., £5,073; H. Middleton, £4,962; Bridge & Engineering Co., Ltd., £4,953; Fram Reinforced Concrete Co., Ltd., £4,782; F. Mitchell & Sons, £4,471; W. & C. French, £4,264.

BALDSLOW.—*Sewage Disposal Works.*—The Battle R.D.C. has accepted the tender of Messrs. Hutchison & Son, St. Leonards, at £1,059, for the construction of sewage disposal works at Baldslow.

BILLINGHAM. — *Silo.* — The Synthetic Ammonia & Nitrates Co. have accepted the tender of the Monnoyer British Construction Co. for the construction of a silo.

CARLISLE.—*Houses.*—The City Council has accepted the tender of Messrs. John Laing & Sons, Ltd., at £34,771, for the construction of 100 houses on the Long Sowerby estate.

DOVER.—*Concrete Bridge.*—The T.C. has accepted the tender of Messrs. G. Lewis & Son, Dover, at £1,680, for the construction of a reinforced concrete bridge over the Dour at Elver.

KILLESTER (CO. DUBLIN).—*Concrete Road.*—The Dublin C.C. has accepted the tender of the Pioneer Road Construction Co., Dublin, at £2,885, for the construction of 550 lineal yards of reinforced concrete roadway from Killester Garden Village to Mount Dillon. Other tenders submitted were: J. Dowling & Co., £3,996; South of Ireland Asphalt Co., £2,928; T. J. Moran & Co., £4,500.

LYTHAM ST. ANNES.—*Concrete Tanks.*—The T.C. has accepted the tender of Messrs. S. & J. Smethurst, Ltd., Oldham, for the construction of two reinforced concrete tanks.

LYTHAM ST. ANNES.—The T.C. has accepted the tender of Messrs. J. Byrom, Ltd., Bury, for the construction of 2,400 yds. of 33-in. concrete main sewer.

MARGATE.—*Concrete Sewer.*—The Corporation has accepted the tender of Mr. W. Ballard, Broadstairs, at £7,240, for the construction of 988 yards of 33-in. and 94 yards of 21-in. concrete sewer.

OLDBURY.—*Reinforced Concrete Bridge.*—The U.D.C. has accepted the tender of Messrs. Jeavons & Co., Tipton, at £5,246, for the construction of a reinforced concrete bridge, 40 ft. wide, 24 ft. 6 in. span, over the canal at Stone Street. Other tenders submitted were: G. Jackson, £9,271; McColvile, £5,252; Bridge Engineering Co., £5,800; A. E. Farr, £6,645.

PENARTH. — *Pier.* — The U.D.C. has accepted the tender of the Yorkshire Hennebique Contracting Co., Ltd., at £5,449, for work in connection with widening the pier.

SHANKLIN, I.O.W.—*Concrete Shelter.*—The U.D.C. has accepted the tender of Messrs. J. Ball & Sons, Cowes, at £465, for the construction of a reinforced concrete shelter on the Homecliff Promenade. Other tenders submitted were: F. C. Construction Co., £675; W. Brown, £475.

TORQUAY. — *Concrete Platform.* — The T.C. has accepted the tender of Mr. W. H. Smith, Strand Chambers, Torquay, at £1,930, for the construction of a concrete platform at Beacon Cove.

TREVOR. — *Concrete Reservoir.* — The Lleyn R.D.C. has accepted the tender of Messrs. Wyatt Bros., Whitchurch, Salop, at £3,644, for the construction of a 45,000-gallon reinforced concrete reservoir, and jointing about 2,810 lineal yards of cast-iron spigot and socket pipes.

WELLINGBOROUGH.—*Concrete Tank.*—The R.D.C. has accepted the tender of Mr. T. Sharp, Earls Barton, Wellingborough, at £140, for the construction of a concrete tank at the pumping station.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XXII. No. 3. LONDON, MARCH, 1927.

EDITORIAL NOTE.

Specifying the Strength of Concrete.

A SYSTEM of specifying the strength of concrete to be used in constructional work is one that has been the subject of much discussion during late years, and is agreed to have many advantages if contractors and engineers can be convinced of its practicability. Such a system would supersede the present custom of specifying the quality and proportions of the ingredients of concrete and attempting to supervise the workmanship. The responsibility for the production of good concrete would thus lie more directly with the contractor, who would have greater freedom in selecting his materials and arranging his methods of working than he is now usually allowed.

By this proposed system the strength of concrete would be ascertained by testing for compressive strength samples of the actual concrete mixings placed in the construction, and if the tests failed to reach the required standard it would be presumed that the concrete in the construction was too weak for its burden and replacement would be demanded by the engineer or owner. The presumption referred to as to the equality in strength of the test pieces and the concrete *in situ* has generally been regarded as reasonable, although there has sometimes been a feeling that the moulding of the test pieces would inevitably be more carefully done than the actual placing of the concrete in the work and thus the compression tests so obtained would represent the maximum strength of the construction. It has also been taken for granted that concrete tests made in a laboratory with given materials would give higher results than test pieces made in the field (field tests) from the concrete mixings used in constructional work.

It is therefore surprising to find from a comprehensive series of investigations made in connection with road construction in North Carolina, first that laboratory tests are on the average lower than field tests of the same materials, and second that specimens of concrete cut out of the road are almost always considerably stronger than test pieces of concrete of the same age made in the laboratory from the same materials. The results of the tests are shown in the table and the graphical record, on p. 184 of this number, and although unexpected it is gratifying to learn that concrete placed in a construction is not always inferior to laboratory tests nor are the latter always the best that can be attained. The subject is an important one and a similar investigation in this country is very desirable.

A question that also needs to be considered is whether the strength of concrete shown to be deficient by field tests should not be checked before demolition of the work by tests of specimens cut from the work.

Water Content.

From what one hears from America the cement-water-ratio method of proportioning concrete is rapidly gaining ground, and is welcomed not only by engineers, who by specifying by this method are assured of the strength of a structure, but also by contractors, who find that it results in an appreciable saving of cement. It is, in fact, on the ground of economy that this method is most widely advocated and put into practice by the leading contractors.

A committee of the American Concrete Institute has recently been studying the subject of proportioning from the economic standpoint, and has arrived at some interesting conclusions. Figures have been obtained from an actual construction job showing the difference in cost of wet and dry concrete of the same strength. The strength required was 2,000 lb. per sq. in. at 28 days. The aggregate consisted of sand graded from ¼ in. to dust and gravel from 1½ in. to ¼ in. It was found that by the exercise of forethought it was possible to use mixes considerably drier than usual for reinforced concrete work, and that concrete with a slump of 3 to 4 in. could be used practically throughout the work. Careful costs were prepared to show the difference in cost of the drier concrete (3 to 4 in. slump) compared with the wetter mix generally used for similar work (6 to 7 in. slump), both concretes giving the same strength. The result was as follows: Concrete with slump of 3 to 4 in.: Cement, 439 lbs.; sand 0·42 cu. yd.; gravel, 0·69 cu. yd.; cost per cu. yd., 19*s.* Concrete with slump of 6 to 7 in.: Cement, 546 lbs.; sand, 0·36 cu. yd.; gravel, 0·72 cu. yd.; cost per cu. yd., 21*s.* 8*d.* The saving was thus 1*s.* 8*d.* per cu. yd., with no loss of strength, and, according to the report, with no extra labour costs owing to the dryness of the mix.

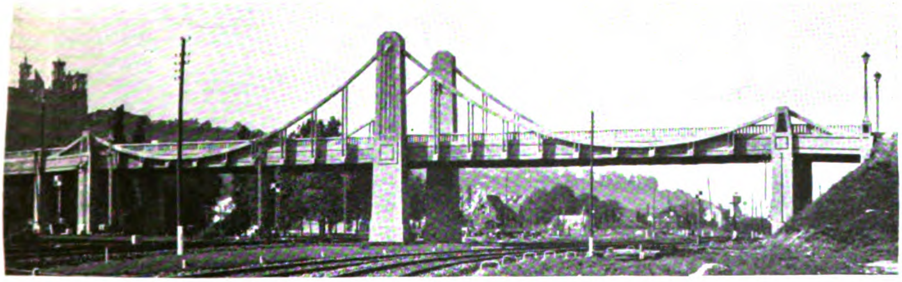
Tables are also given comparing a 1 : 2 : 4 concrete with a concrete designed to give a strength of 2,000 lbs. per sq. in. at 28 days. These comparisons are given for concretes made with different size aggregates, and show extra costs of 1 : 2 : 4 mixes ranging from 1*s.* 2½*d.* to 2*s.* 5½*d.* per cu. yd. according to grading; that is, the difference was less when the coarse aggregate was graded from ¼ in. to 1½ in. than when it was graded from ¾ in. to 1½ in.

Mr. J. G. Ahlers, a member of the committee, stated that in the case of a seven-story reinforced concrete warehouse built by his firm, preliminary tests showed that a 1 : 2 : 4 concrete would cost 26*s.* per cu. yd., whereas by designing the mixture to produce a 2,000-lb. concrete at 28 days the actual cost was 23*s.* 4*d.*, a saving of 2*s.* 8*d.* per yd. In this case a total of 1,494 cu. yds. were used, so that the total saving effected was £174 6*s.*

We hope to refer again to this important report in our next number, and in the meantime would refer to a notice on page 228 of this number announcing the publication of a shilling booklet giving a complete account of the method of designing concrete mixes for pre-determined strength.

Consulting Engineers' Contracts.

THE Institution of Structural Engineers has recently produced a form of contract between the client and the consulting engineer, which can be obtained at the price of one shilling from the secretary of the Institution. The issue of this document remedies a long-felt need for a printed record of definite and authoritative rules governing the relations between client and consulting engineer, which are too often left more or less indefinite and vague and may thus be the cause of much trouble and vexation when the question of fees and their rate of payment arises. Just as the R.I.B.A. form of contract defining the relations between client and contractor has proved a boon to both parties, and is widely used as the actual contract or as the basis for one, so it may be anticipated that this form will be welcomed by both consulting engineer and client as defining the usual and accepted practice. The contract is printed in two distinct forms, one for use where a Bill in Parliament is contemplated and one for use without a Bill, and they are both supplemented by the rules of the Institution giving scale of fees and containing provision for payment in the event of extra work being carried out or in the event of the works being abandoned. These rules should be attached to and form part of the contract, so as to make it really self-contained. The document is a useful and serviceable one for both parties, binding the engineer to the proper carrying out of certain duties which are explicitly set out together with his responsibilities, and on the other hand binding the client to pay the proper scale fees for the work which is being carried out for him.



Reinforced Concrete Suspension Bridge.

[THIS bridge has recently been completed at Vaux-sous-Laon, Aisne, France. The columns are provided with a bearing both at top and bottom to allow for expansion and contraction of the flooring of the bridge; this device is the invention of M. Freyssinet. The spacing of the columns varies from 42 ft. to 59 ft.

The design of the bridge was dictated by the fact that the distance to be spanned was 230 ft. and only one intermediate support could be introduced. The central pylons are 65 ft. 8 in. in height, and to these the reinforced concrete "cables" are fixed in one direction only. The ties between the deck of the bridge and the "cables" are spaced at 11 ft. 6 in. centres. The work was carried out by the Société des Entreprises Limousin, under the direction of the chief engineer to the Northern Railway Company.]

Comparison of Field and Laboratory Test Pieces.

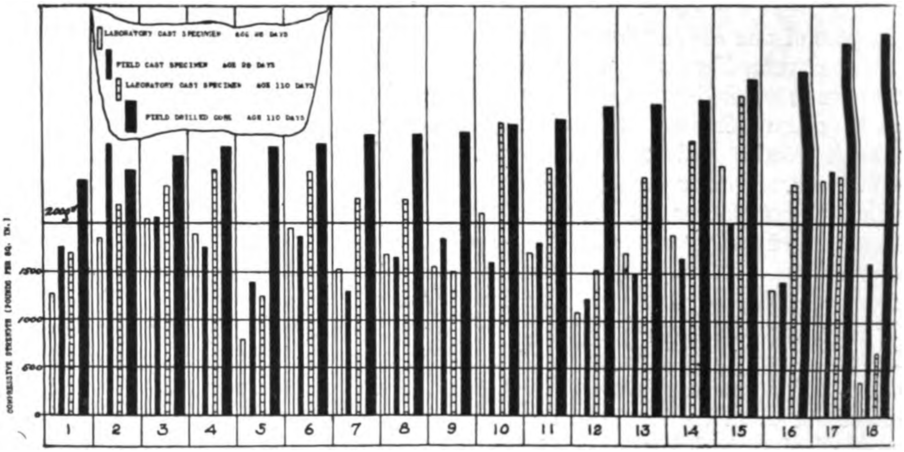


Chart showing the effect of variables encountered on 18 investigations of the compressive strength of 1 : 2 : 4 concrete when tested by means of laboratory cast cylinders, field cast cylinders and cores drilled from the finished structure. All specimens in each set were made from a given batch of materials. Each result is the average of 4 or 5 specimens.

Project Number	1	2	3	4	5	6
412	1779	1291	1781	2244	1717	2479
577	1692	1871	2856	2315	2209	2586
535	1779	2071	2080	2244	2419	2731
588	1692	1909	1762	2315	2587	2822
765	1692	800	1400	2315	1255	2831
428	1692	1977	1893	2315	2572	2859
670	1779	1548	1310	2244	2289	2954
484	1799	1696	1665	2421	2275	2958
473	1779	1572	1872	2244	1516	2996
463	1799	2132	1606	2421	3071	3063
614	1779	1707	1815	2244	2607	3129
629	1799	1098	1238	2421	1537	3265
742	1799	1711	1491	2421	2509	3297
528	1779	1907	1662	2244	2900	3333
429	1692	2643	2044	2315	3382	3557
785	1799	1327	1408	2421	2441	3623
741	1799	2481	2574	2421	2520	3927
790	1799	370	1610	2421	662	4018

NOTE:

Column 1. Laboratory standard concrete—28 days—average five specimens.

Column 2. Laboratory concrete from the materials sent from field to laboratory. Made and cured under laboratory conditions identical with those of Column 1. Age 28 days—average five specimens.

Column 3. Field concrete. Specimens cast from concrete deposited in roadway, cured under field conditions for 21 days and then packed in damp sand and shipped to laboratory for test at 28 days. Average five specimens.

Column 4. Same as Column 1; test age 3½ months.

Column 5. Same as Column 2; test age 3½ months.

Column 6. Field drilled core—age 3½ months.

All laboratory specimens made to conform as nearly as possible to the consistency of that used in field. All specimens corrected to strength of 6 × 12 in. cylinder.

(See p. 181.)

Secondary Stresses due to Restraint at the Corners of Long Tanks.

By GORDON WELCH, B.Sc., A.C.G.I., A.M.Inst.C.E.

In designing certain tanks and reservoirs of length considerably greater than the depth, it is often most practicable to reinforce the walls vertically, spanning between the floor and the roof or a cope beam provided along the top of the tank wall. The calculations for the bending moments and the amount of vertical reinforcement required in the wall may be made in the usual way according to the amount of fixity assumed to exist at the bottom and top of the tank.

The secondary stresses due to restraint at the corners of such tanks present an intricate problem in design, and although it may not be possible to determine mathematically the exact value of these stresses, owing to the variety of ways in which these can distribute themselves, it is hoped that the following analysis on rational lines may be of interest, and helpful in apportioning the steel reinforcement to cover the risk of cracking in the concrete.

That these secondary stresses must exist is easily seen from considering *Figs.* 1 and 2. In *Fig.* 1, *A B* represents the wall of a reservoir reinforced from *B* to *A*. Under the pressure of water in the reservoir this wall will deflect as shown in the figure; the shape of this deflection curve and the amount and position of the maximum deflection will depend upon the amount of fixing at the base and top of the wall.

If now we take a horizontal section of the wall at a level where we get some deflection y, the wall held at the ends by the end walls will have assumed a shape as shown in *Fig.* 2. That part of the wall so far removed from the corners as to be unaffected by the restraint at the ends will have deflected an amount y from the straight unstressed position, but at the ends where no deflection is possible bending stresses as well as direct tensile stresses will be set up. It is the object of the following analysis to determine the maximum values of these stresses due to restraint at the corners of the tank.

Let us consider any horizontal strip of wall 12 in. deep at the corner of the tank, as shown in *Fig.* 3. Let its unstrained position be *A B* and its position under the water pressure be *A C* with a deflection $B\,C = \triangle$ The load due to the water pressure on this strip of wall will be at *A* equal to the head of water at the level considered, whilst at *C*, where the maximum deflection is reached, this pressure will be carried wholly by the vertical spanning of the wall and the beam *A C* will be relieved of its load at this point. Between the points *A* and *C* the load on *A C* is assumed to vary uniformly, as shown in the figure.

Now, for such a beam fixed at one end in position and direction and fixed in direction only at the other, we have for the form of loading assumed,

$$M_A = -\frac{p.l^3}{8} : M_C = +\frac{p.l^3}{24} \text{ and } \triangle = \frac{p.l^5}{80E.I.}$$

where $p.l.$ = pressure per square foot due to the head of water at the depth considered.

Beyond the distance l the wall spans wholly vertically, and for the case of a

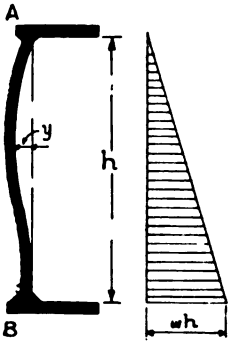


FIG. 1.

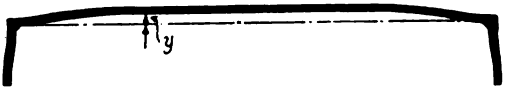


FIG. 2.

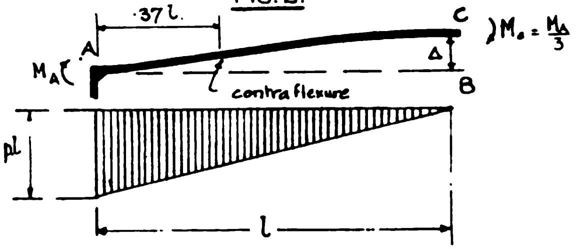
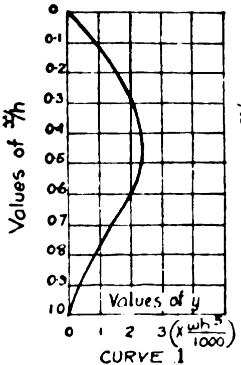


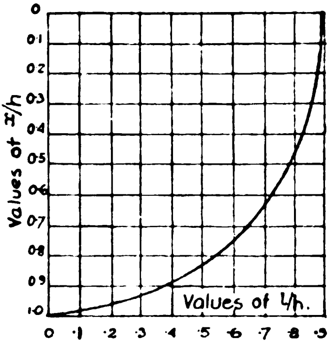
FIG. 3.

Values of x/h	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9	———
" " y	0·82	·1·54	2·07	2·35	2·34	2·05	1·52	0·87	0·27	Multiply by $\frac{wh^5}{1000}$
" l/h	0·898	0·882	0·861	0·827	0·782	0·722	0·645	0·543	0·392	———
" " M_A	1·01	1·95	2·76	3·43	3·82	3·90	3·63	2·95	1·73	Multiply by $\frac{wh^3}{100}$

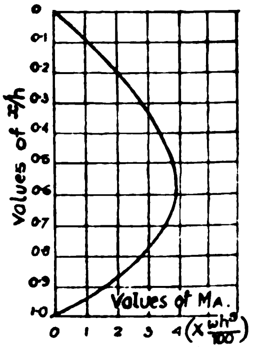
NOTE: The values of y are for Homogeneous Beams only.



CURVE 1



CURVE 2.



CURVE 3.

wall of height h, fixed at the base and freely supported at the top, the deflection at any depth x from the top of the tank will be, for the vertical beam,

$$y = \frac{w}{120E.I}\left[h^4 \cdot x + x^5 - 2h^2x^3\right]$$

where w = weight of a cubic foot of water.

The water pressure $p.l$ at this depth will be $= w.x$.

And the deflection, for the horizontal beam will be

$$\triangle = \frac{w.x.l^4}{80EI.}$$

For any particular depth these deflections y and $\triangle$ must be the same, so that if in the two equations we substitute successive values of x in terms of h and equate y and $\triangle$ we can find the values of l, the effective length of that portion of wall under restraint, and knowing l we can calculate the values of M_A at these depths.

It should be noted that the above equations for the deflections y and $\triangle$ are strictly true only for homogeneous beams, and for reinforced concrete should be modified by factors which according to Turneaure and Maurer depend upon the value of n and the percentage of steel in the beams. The value of n may be assumed constant, however, for the two elementary beams considered, and the percentage of steel required both at the corners and vertically in the wall may as a first approximation be assumed equal. It will not be necessary therefore to depart from the above formulæ, as in equating y and $\triangle$ the constants mentioned will cancel out.

This has been done, substituting values for $x = 0{\cdot}1h$, $0{\cdot}2h$, and the curves 1, 2 and 3 plotted showing the variation of the deflection y, the effective length l, and the restraint moment M_A, all for the case of a wall fixed at the base and hinged at the top.

At first sight it might have been assumed that the maximum value of M_A would occur at the level of the maximum deflection, i.e. at a depth of $0{\cdot}447h$, but on reference to the curves it will be seen that the maximum value occurs somewhat lower, being at about the depth $0{\cdot}57h$, when $M_A = \frac{wh^3}{25}$ nearly. This is a moment less than the maximum negative moment due to fixation at the base of the wall, but greater than the maximum positive moment occurring about halfway up the wall.

If the wall be considered hinged at the base and at the top, the maximum value of M_A will be about $\frac{wh^3}{15}$, or approximately the same as the maximum positive moment in the wall where simply spanning vertically. From these conclusions we see that practically the same percentage of steel will be required at the corners as in the wall itself, and that the equations for the deflections will be in the ratio we have assumed.

In addition to the bending stresses there will also be stresses of direct tension due to the tendency for the walls to burst away at the corners. The measure of these tensile stresses will be, at any depth, the total load on the horizontal elementary beam at that depth ; or referring again to *Fig.* 3 the direct tension on a strip of wall 12 in. wide will be $= \frac{p.l.^2}{2}$ At any depth $= x$, $pl = w.x$; hence this direct tension at a depth x is given by

$$t = \frac{w.x.l}{2}.$$

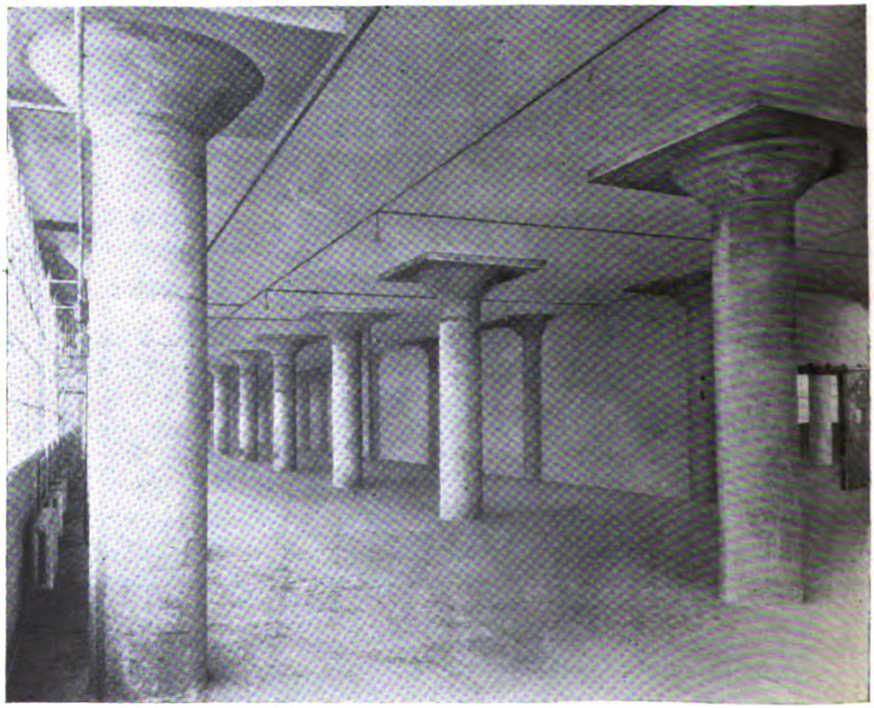
By inspection of curve 2 this will be a maximum when $x = 0{\cdot}7h$ (approx.) and

$$t_{(max.)} = 0{\cdot}22wh^2$$

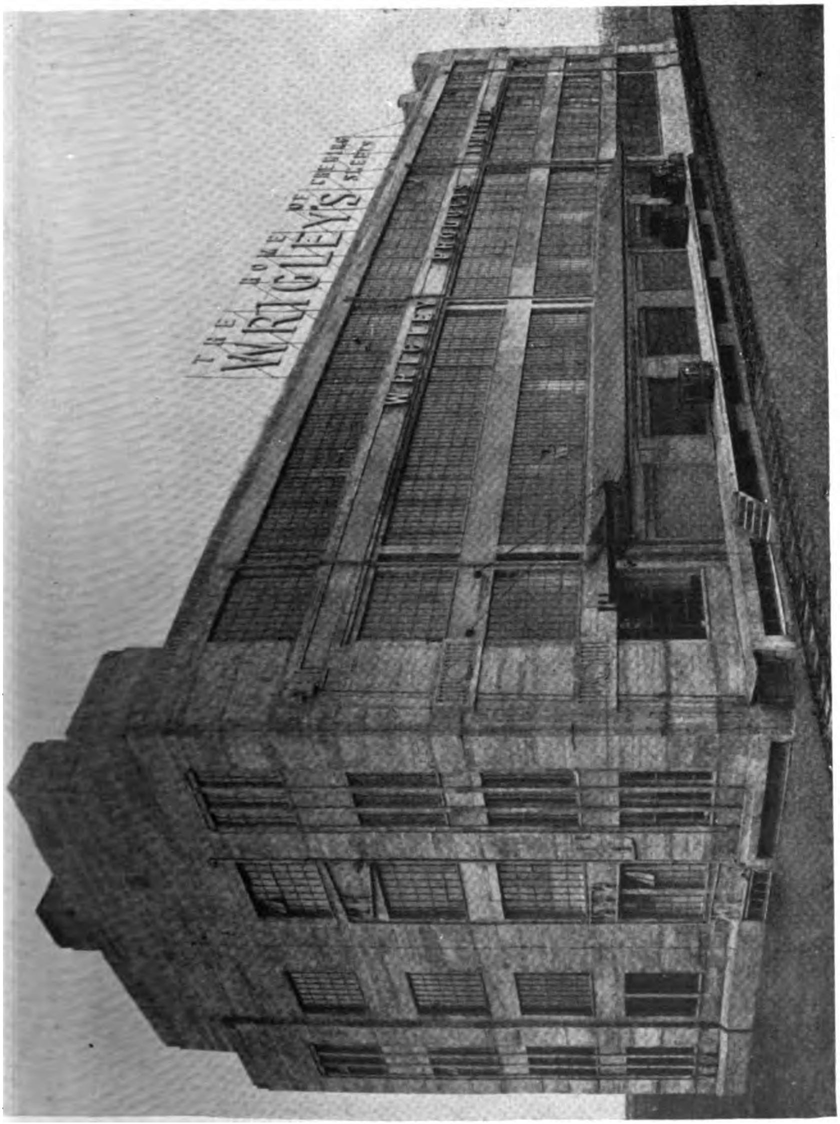
Sufficient steel should therefore be provided, in addition to that required for bending, to take half of this tension, the other half being taken by the concrete by reducing its compressive stress due to bending.

It is possible, due to the tendency for the wall slab near the ends of the tank to span diagonally from the bottom of the tank to the end wall, that the actual restraint moments will be less than as found here. It is difficult, if not impossible, to say, however, to what extent this action will help, and it would be on the side of safety to neglect this effect.

It will be seen from the values of l in terms of h found above that this analysis cannot apply to cases where the length of the sides of the tank are not at least equal to twice the height. In cases where the length is less than twice the height the wall must be considered as a slab supported on four sides.



Flat-Slab Construction at a Factory at Wembley. (*See p.* 189.)



[*Messrs. Wallis, Gilbert & Partners, Architects,*

Reinforced Concrete Factory at Wembley.

Particulars of this factory, with flat slab floors, were given in our number for November, 1926. The design is by the Trussed Concrete Steel Co., Ltd., and the contractors were A. Roberts & Co., Ltd.]

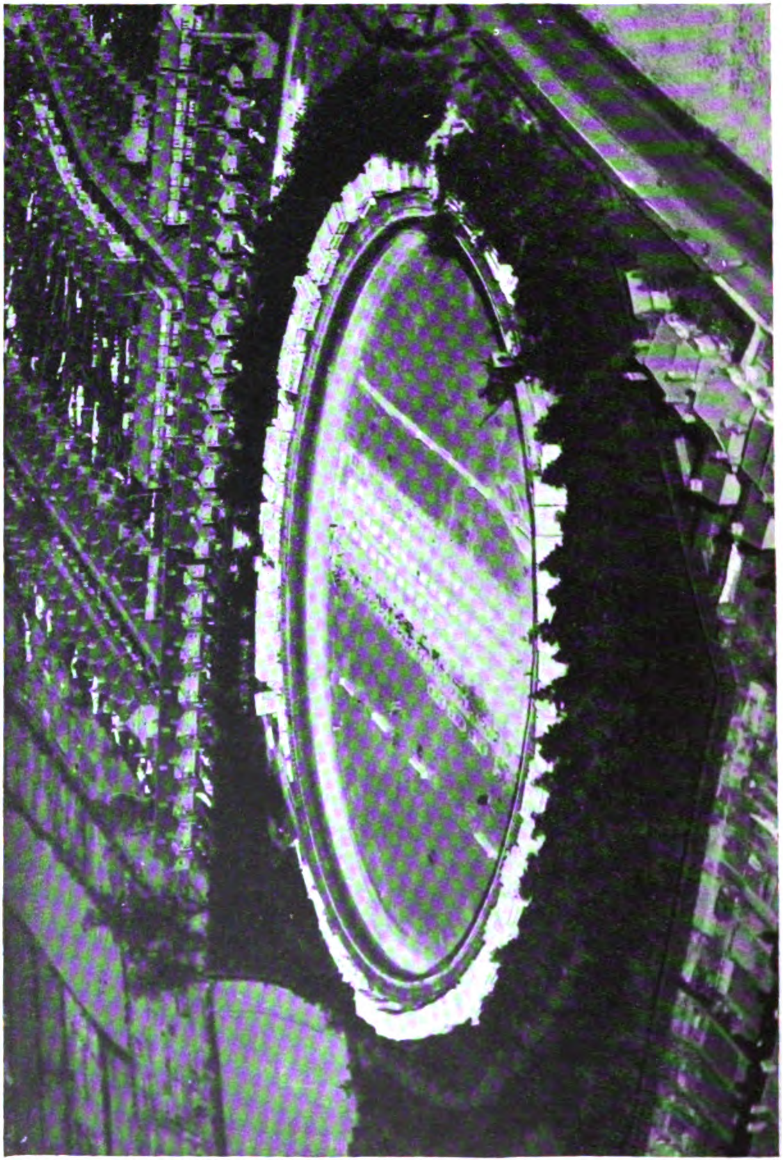


Fig. 1.—Reservoir at Erdington before Covering with Pre-Cast Members. *(See p. 191.)*

Pre-Cast Concrete Reservoir Covering.

THE covered service reservoir described and illustrated in the present article was constructed for the Birmingham Corporation Water Department at Erdington, under the direction of Mr. F. W. Macaulay, M.Inst. C.E., the engineer, on a site on high ground about four miles from the centre of the city.

Fig. 1 is a view of the reservoir before the construction of the covering, but all round the margin may be seen stacks of pre-cast columns, beams and slabs, seasoned in readiness for rapid execution of the covering works.

The reservoir basin is oval in plan, measuring 400 ft. on the major axis by 300 ft. on the minor axis. It provides for a 20-ft. depth of water and measures 24 ft. from foundation level to the top of the roof. The walls curve inwards, finally merging imperceptibly with the floor of the reservoir, the latter having a fall of 1 in 200 towards a central drainage channel. The walls are of mass concrete, having a maximum thickness of nearly 6 ft., tapering to 2 ft. 3 in. at the top, and are backed up all round by a substantial earthen embankment. They are faced with blue Staffordshire bricks, set in 1 : 1½ cement mortar, a waterproof lining of asphalt, ½ in. thick, being laid between the brickwork and the concrete. The floor is of concrete, 12 in. thick, also covered with a ½-in. layer of asphalt.

The covering consists of pre-cast slabs and beams, supported by pre-cast columns fitted and grouted into extended reinforced concrete footings moulded *in situ* on the floor of the reservoir. *Fig.* 2 shows some of the pre-cast members stacked in readiness for use in the reservoir, and *Fig.* 3 illustrates the slinging of a pre-cast column.

The footings on the floor are spaced 13 ft. apart longitudinally and transversely, but those along the foot of the oval boundary wall are at considerably shorter and varying distances from the footing on the floor proper. The footings are 4 ft. square in plan and each was moulded with a socket for receiving a rectangular spigot at the foot of the column to be afterwards erected and grouted in place. In order to provide for all the columns to be cast of uniform length, the extended footings were brought up to the predetermined level by increasing the thickness of the concrete to compensate for the progressive fall of the floor to the centre. *Fig.* 4 is reproduced from a photograph taken after completion of the footings and when

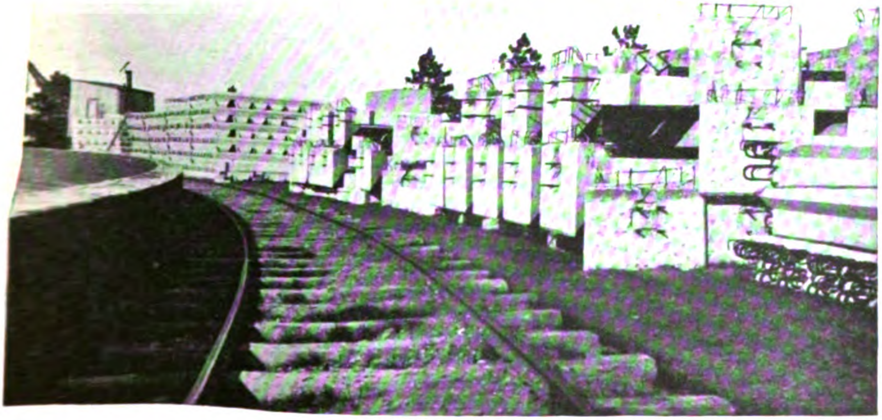


Fig. 2—Some of the Pre-Cast Members.

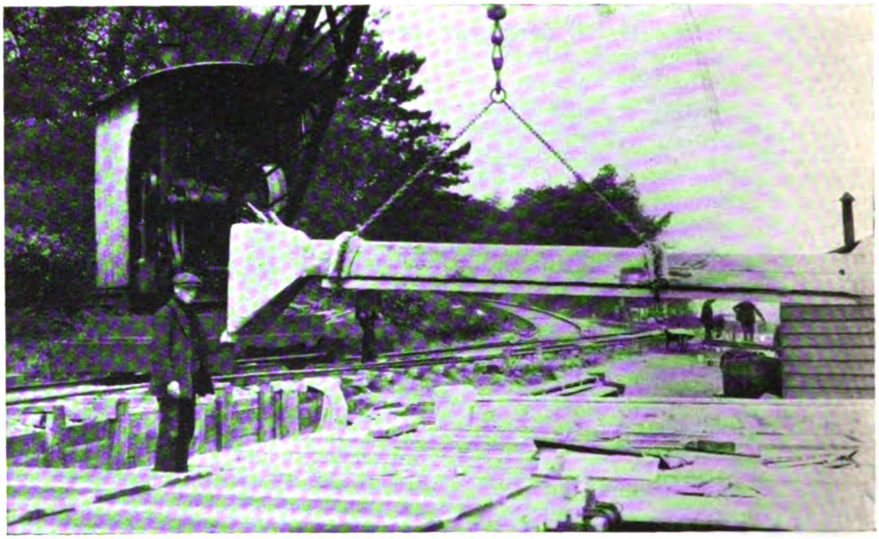


Fig. 3.—Slinging a Pre-Cast Column.

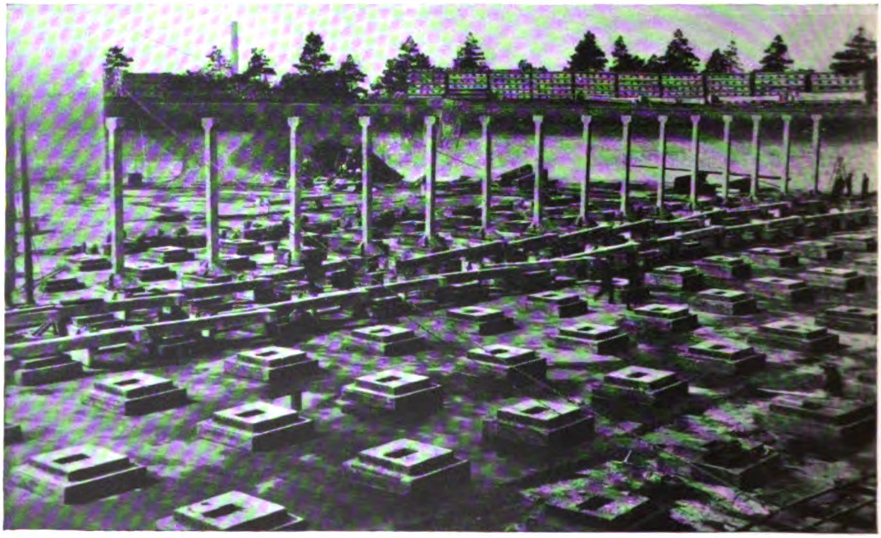


Fig. 4.—Footings and some of the Columns in Position.

the erection of the columns had just been commenced.

The pre-cast reinforced concrete columns are 12 in. square, each having an extended base designed to provide an ample bearing on the footing, and also having an extended head for the support of the beams. The longitudinal reinforcing bars of the columns were left projecting about 15 in. above the concrete, in order that the projecting hooked ends of the main reinforcing bars of the beams might be looped over them and so form a series of strong mechanical links between the two classes of structural members. During the erection of the columns one of these members fell before it had been grouted up, with the result that all the others in the same row were knocked down very much like "nine-pins." On examination, however, the concrete was found to be only slightly cracked in one column only. The damaged material was cut out and made good with rapid-hardening Portland cement concrete, and after seven days the columns were re-erected and found to be perfectly sound.

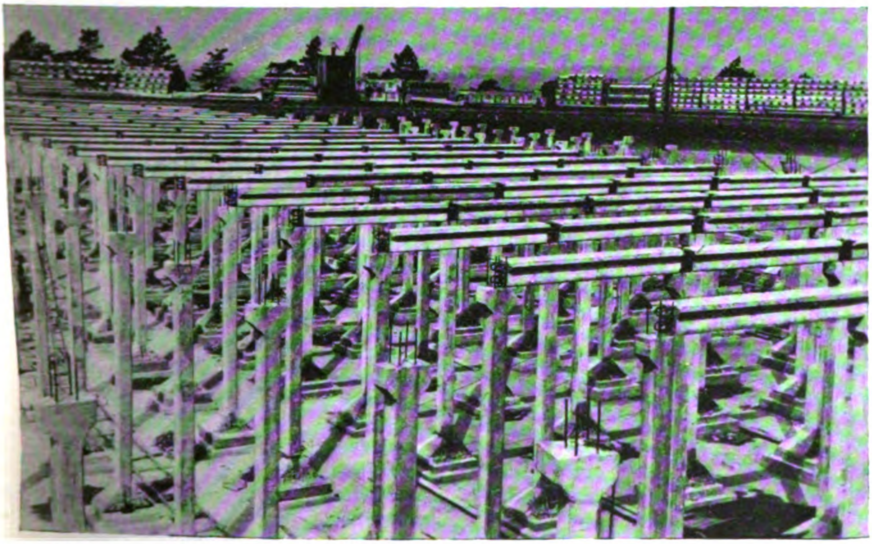


Fig. 5.—Columns and Beams in Position. Ready for Roofing Slabs.

The beams, also of reinforced concrete, were pre-cast to a uniform length of 12 ft., with the exception of the shorter beams connecting the marginal with the adjacent interior columns. As the spacing of the columns is 13 ft. from centre to centre, there was a distance of 12 in. between the ends of adjacent beams to provide for the linking of the reinforcing bars, the intervening space being afterwards filled in with concrete. The beams are 16 in. deep by 16 in. wide at the top, shaped off to 8 in. wide at the bottom so as to form an approximately T-shaped cross section. *Fig.* 5 shows a considerable number of the columns and beams in place, before the addition of the roofing slabs.

Upon the beams are carried slabs of trough section, pre-cast in widths of 24 in. and with a length a few inches less than that of the beam spacing. The slabs are 3 in. thick, each having two 6-in. projecting ribs, which form the trough shaped section, and the edges above the ribs are chamfered off to a depth of 7 in. When assembled, the slabs are placed with the trough inverted so that the projecting ribs come together and form a series of beams below the slabs, while the chamfered edges of contiguous slabs form a series of V-shaped grooves, the latter being filled in with concrete. The spaces between the ends of the slabs are similarly filled with concrete, making a monolithic connection between all elements of the roof covering. This simple method of slab construction resulted in a great saving of time and labour, as it entirely obviated the necessity for moulding and erecting separate beams or ribs for stiffening the slabs. Equal saving was effected by the methods adopted in the design and construction of the columns and main beams.

The reservoir is provided with numerous ventilation chambers, access manholes, and the necessary inlets, outlets and provision for wash-out and overflow pipes. The roofing, calculated for a super load of 1 cwt. per sq. ft., is covered to a depth of 12 in. with earth as a protection against temperature variations.

The whole of the work was carried out within twelve months to the designs and under the superintendence of Mr. F. W. Macaulay, M.Inst.C.E., the City Waterworks Engineer, by Messrs. Wilson Lovatt & Sons, Ltd., of Wolverhampton. Details of the reinforced concrete construction were prepared by Messrs. L. G. Mouchel & Partners, Ltd., of Westminster.

Hydraulic Cement with Refractory Properties.

ENGINEERS engaged in the construction of the various classes of industrial plant which require the use of refractory materials or linings will be interested in the discovery of a cement which is stated to be able to withstand high temperatures when used as a jointing material for refractories or as a constituent of a refractory concrete.

Researches organised by M. P. Kestner have resulted in the marketing of a cement for which remarkable properties are claimed. An account of these researches has appeared recently in *Chimie et Industrie*, from which the following notes have been compiled.

The object of the research work was to discover a cement which would (1) set when cold, with the addition of water, and not contract while setting; (2) keep its strength at high temperatures; (3) not show cracks or dangerous amounts of expansion after heating; (4) withstand very high temperatures without melting.

In carrying out the experiments, three cements, Portland, magnesian, and aluminous, were tried in turn with various admixed materials. The two former were ultimately abandoned as not being likely to give favourable results. By mixing one part of aluminous cement with two parts of bauxite calcined in a vertical kiln and then ground, a cement was obtained which was capable of resisting high temperatures. The bauxite contained less than 12 per cent. of Fe_2O_3. The resulting cement is slow setting and quick hardening. The strength at three days is 2,030 lb. per square inch in compression and 300 lb. per square inch in tension.

A refractory concrete may be obtained by using as aggregate old refractory bricks, etc., broken to a suitable size and unscreened. Washing the broken material is desirable in order to remove the very fine dust. This washing process is beneficial from the point of view of preventing the dry aggregate from soaking up the water used in gauging the cement.

Both the cement and the concrete have a very small contraction, about 1 per cent. at 1350 deg. C., and even less in some cases. Small concrete specimens carried quickly from a temperature of 1380 deg. C. to a room whose temperature was 20 deg. C. did not exhibit any cracks due to the cooling process.

Some graphs accompanying the article show the strength of concrete, made with this cement, in compression after heating to high temperatures. For temperatures between 1000 deg. C. and 1300 deg. C. the strengths average about 480 lbs. per square inch.—W. S. G.

Reinforced Concrete in India.

FUSE FACTORY AT KIRKEE.

By R. P. MEARS, M.Inst.C.E.

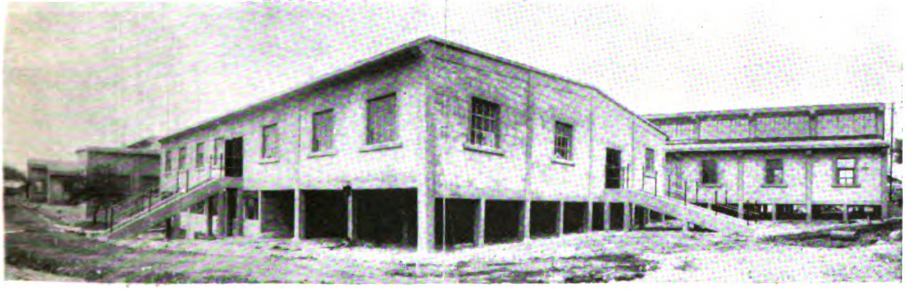
A LARGE Government Ammunition Factory has existed for many years at Kirkee near Poona. During the war it was greatly enlarged, and most of the buildings then added were constructed in reinforced concrete.

In order to manufacture up-to-date fuses it has been found necessary further to add to the enlarged factory, and the building shown in the accompanying photographs was decided on.

Work was commenced in October, 1924, and the whole building with the plant for controlling its atmospheric conditions has recently been completed. The buildings are of reinforced concrete throughout, and were designed and constructed by Messrs. J. C. Gammon, Ltd., of Bombay, to the general requirements of the Director of Ordnance Factories in India, and were erected under the supervision of the Commanding Royal Engineer, Poona, and the Garrison Engineer of Kirkee.

This large factory covers an area of over 50,000 square feet and is lighted with north light roofs consisting of reinforced concrete trusses of 20 ft. span built *in situ* carrying a reinforced concrete slab of varying spans averaging about 15 feet. This slab is for the greater part 10 in. thick, reinforced with ¾-in. bars at 14-in. centres. For the sake of coolness and obtaining an even temperature, this 10-in. slab is not only made with hollow concrete blocks placed below the neutral axis and between the reinforcement in the usual manner employed in the construction of hollow floors of considerable span, but is covered on the top with a further layer of hollow blocks of 4 in. thickness. These are brought to an even surface in mortar, and then the whole is covered with Messrs. G. M. Callender & Co.'s "Veribest" roofing felt bedded and covered in bituminous mastic applied hot. The surface is sanded.

The walls to those portions of the buildings which are to be "air conditioned" are constructed hollow. This results in a very cool factory as shown by the following figures of temperature readings taken on a hot afternoon in April. The shade temperature in a building near by under an ordinary roof was 97 deg. F.; simultaneous readings inside the factory varied between 89½ deg. F. and 86½ deg. F. These readings were taken before the special plant for controlling the internal temperature and humidity had been brought into use.

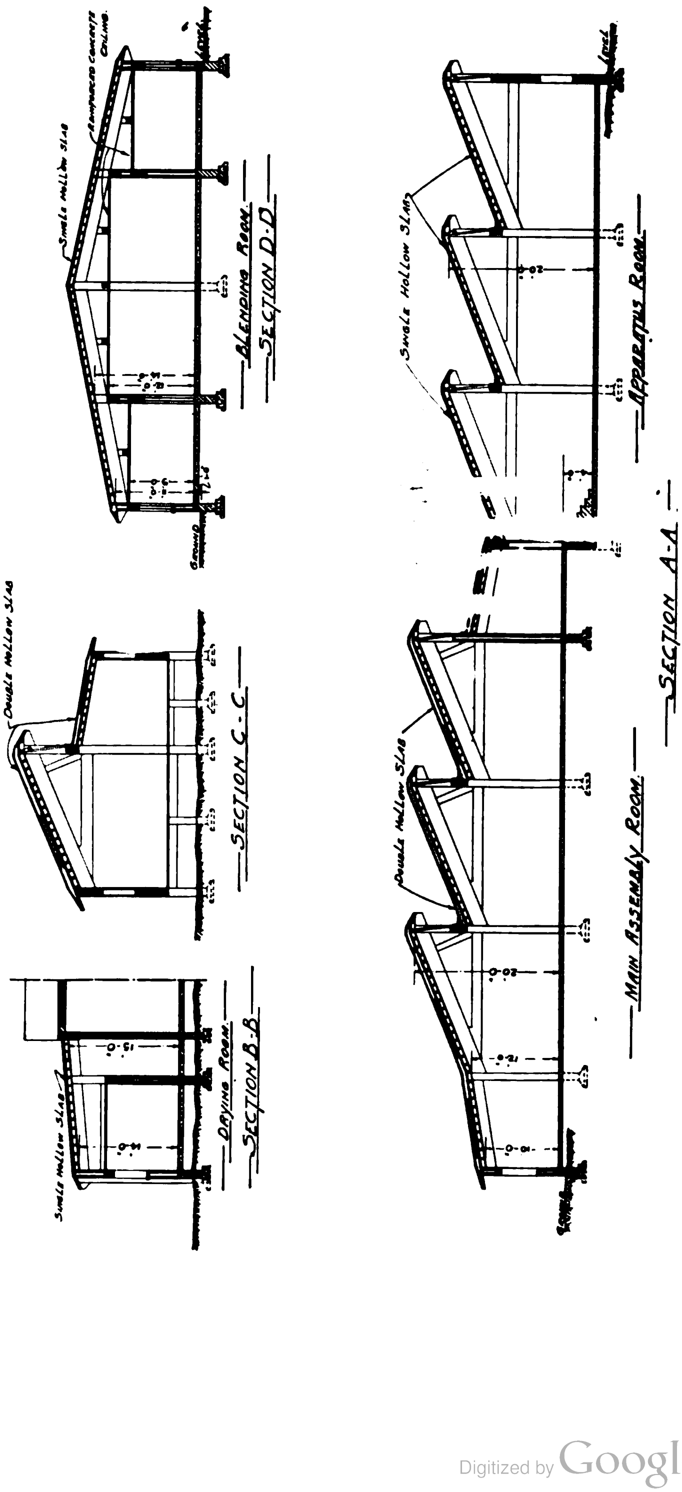


Reinforced Concrete Fuse Factory at Kirkee.

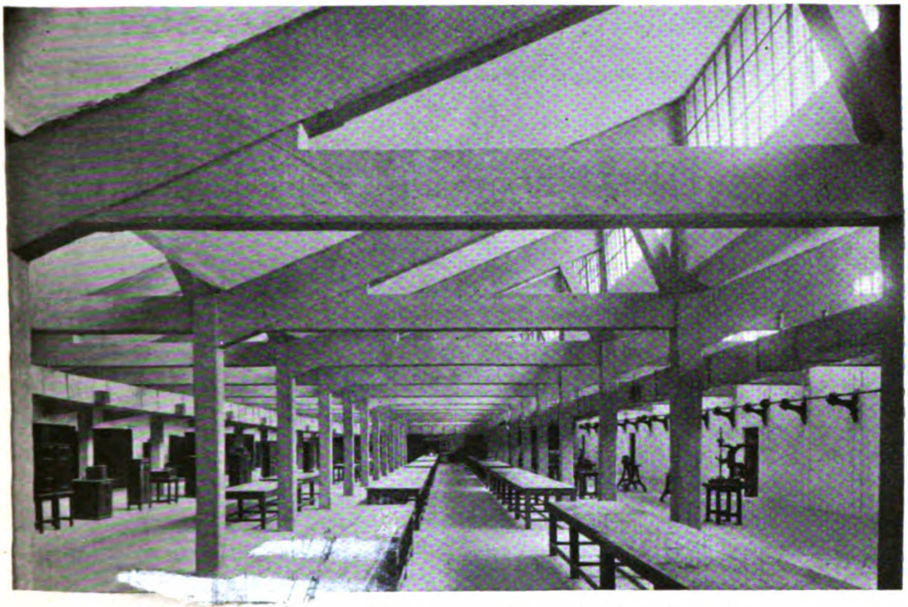
The site of this building is about 70 miles from the West Coast of India and is at a height of nearly 2,000 ft.; this accounts for the comparatively low temperature figures taken at the commencement of the hot season.

The accompanying sections show the features of the design, consisting of double hollow walls, double hollow block roofs, and, in some cases, of suspended ceilings in reinforced concrete.

The hollow blocks were mostly made of concrete in wooden moulds close by, and



Reinforced Concrete Fuse Factory at Kirkee.



Reinforced Concrete Fuse Factory at Kirkee : Interior.

then thoroughly immersed in large tanks specially constructed, as without such precautions all pre-cast blockwork perishes rapidly while green under the influence of the sun and hot dry winds. Hollow bricks and hollow tiles are most difficult to procure in this part of India, as they are mainly manufactured in the extreme south and cost much in both initial cost and freight. Further, it takes many months to get them manufactured and delivered.

Contraction and Expansion of Concrete.

We regret some decimal points were displaced in the note under the above title in our last number. The note should read as follows :

" A microscopic examination of concrete under contraction reveals cracks about 0·01 mm. in width followed by cracks of a magnitude of about 0·04 mm. which are visible to the naked eye.

" An ordinary 1 to 5 concrete, with a strength of 2500 lbs. per sq. in. at 28 days, shows the microscopic cracks with ·01 per cent. expansion. Cracks visible to the naked eye appear in plain concrete when the expansion is ·014 per cent., and in reinforced concrete at the higher value of ·018 per cent. Recent experiments, described in 'Zement,' prove that the cracks appear at a much earlier stage than was formerly suspected. The question of how to prevent cracks due to hardening is of great importance in the construction of concrete roads, tanks, and long slabs. It has been found that the alternation of wet and dry weather is responsible for changes in length of the magnitude of about ·03 to ·04 per cent. It is essential to keep the concrete damp while the hardening process is taking place. Concrete maintained damp exhibited a contraction of only ·008 per cent., compared with ·032 per cent. for concrete which was allowed to dry."

Polishing Portland Cement Concrete.

By J. SINGLETON-GREEN, M.Sc., A.M.I.Mech.E.

Although it is not possible to get a genuine polish on concrete except by glazing, there are ways and means of obtaining a face which will vary in glossiness according to the methods adopted.

The essential point to appreciate is that in attempting to polish Portland cement concrete, two distinct materials, namely, the aggregate and the cement, are being dealt with. The nature of the cement after it has set in concrete is such that it will not take a polish. It is possible, of course, to get a smooth, and even a shiny, mirror-like face, but this will not be comparable with the polish which can be given to a fine-grained stone. Further, any shiny effect produced on the surface of the cement will generally only be temporary in character unless the specimen is put under a glass case—a few rubs with the finger will be sufficient to spoil its glossy appearance.

It will be clear, then, that the aggregate must be relied upon for polished effects. The first consideration is the nature of this material, for one which is fine in grain and hard is better than a coarse-grained soft material. On the choice of aggregate will depend the degree of polish attainable; marble and granite are good in this respect.

The second consideration is the proportion of aggregate to cement. From the polishing point of view a surface consisting entirely of aggregate would be best, and therefore the aim should be to get as much aggregate on the surface as possible.

In cases where some approximation to a polish is necessary, the aggregate should be well graded with perhaps an excess of small particles ($\frac{1}{8}$ in. to $\frac{1}{16}$ in.), so as to leave comparatively little cement to be seen. When cost is an important factor it should be remembered that large aggregate gives more trouble in rubbing down to a face. Half-inch aggregate is probably large enough.

For a floor, a method often adopted is to sprinkle the aggregate on top of the wet bed of cement and well roll it in.

A good method of obtaining a high proportion of aggregate at the surface in pre-cast work is as follows: A coating of glue is applied to the face of the mould, and the aggregate is then placed on the glue in the position required. This system is adopted when certain patterns are desired or when a definite arrangement of fine and coarse aggregate is to be obtained, as if glue were not used there would be risk of displacement of the pieces of aggregate when the concrete proper was placed and tamped in the mould. In certain classes of work, especially where the mould (or other medium upon which the facing material is thus temporarily mounted) is likely to be subjected to heat, or where it may be stored in a damp place, it is probable that shellac dissolved in naphtha will be preferable to glue. One particular firm manufacturing mosaics uses thin shellac varnish.

In floors, care must be taken that the surface is packed with aggregate, as indicated. It is left for about three days, and then the top film of cement and some slight thickness of the stone beneath is scrubbed away with coarse emery stones until an even appearance of the aggregate is produced; parts which show a preponderance of cement and little aggregate are gone over until the whole floor is even in appearance and level.

The rubbing leaves the surface rough and scratched, and the cement parts show small gaps and pinholes. A coat of

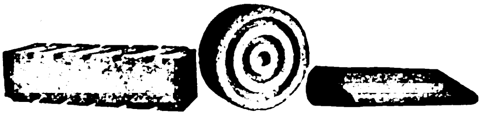


Fig. 1.—Types of Carborundum Rubbing Bricks.

cement grout is washed over it, well rubbed in with emery stones, and then left to set. A day or two later it is gone over with fine-grained sandstone (ordinary blue York is about right). The rubbing is done alternately in one direction and at right angles to that direction until a fine face free from scratches is produced.

Floors are generally left at this, as this treatment makes them smooth enough for their purpose.

Carborundum is now used extensively for surfacing concrete floors. Blocks of carborundum are made in a wide variety of shapes, sizes, and grits for both machine and hand work, and it is claimed that they cut so fast that a workman can cover more floor area in a given time, and produce a more uniform finish with less effort, than when sand or natural stone is used. *Fig.* 2 shows a carborundum rubber to be used for mosaic and terrazzo floors.

It is often desired to give a wall surface a polished or glossy appearance, and for this work a preliminary scrubbing down with a carborundum brick is to be recommended. *Fig.* 1 shows types of carborundum rubbing brick. The round and rectangular fluted bricks are used for removing marks left by formwork and for surfacing generally, and the special edge slip stone is used for smoothing out corners, coves, bases, and places which are difficult or impossible to reach with round or rectangular bricks. The flutes give a shear cutting action and allow a clearance for the material removed in the grinding process.

If a high polish is desired the floor should be cleaned and dried thoroughly and given a coat of size. It can then be polished with any good wax floor polish.

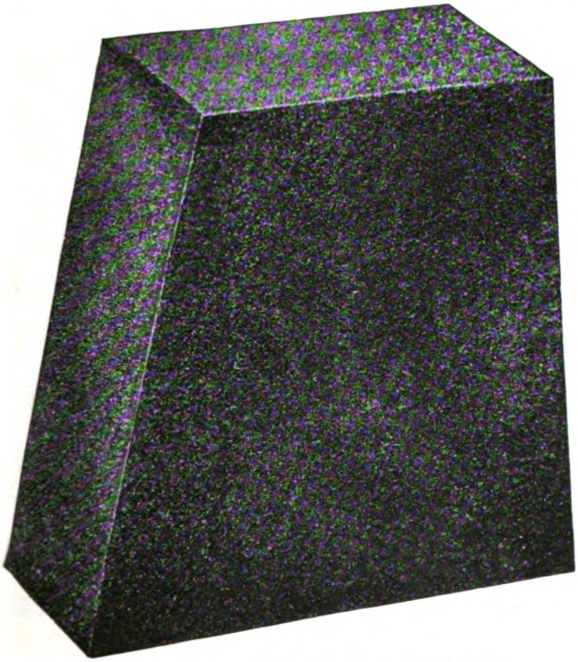


Fig. 2.—Carborundum Rubber for Floors.

A suitable floor surfacer is made by the "Cavicchi," supplied by Messrs. Hall, Phillipson & Co., Ltd. The machine is simple in design and built to withstand rough usage. It is equipped with a 2 h.p. interchangeable electric motor, and can be used in very small spaces. The capacity of this machine, which is operated by one man, is 500–800 super ft. of terrazzo floor per day, thus equalling the work of 8 or 10 men rubbing by hand.

Other machines are supplied by the

company for dealing with walls, stair treads, risers, patches, coves, etc.

A polishing machine made on the Continent uses a petrol engine for motive power. This, of course, is an advantage when electric power may not be available, as, for instance, in an unfinished building.

The degree to which an existing floor can be polished will depend on the nature and proportion of the aggregate. First, the floor is rubbed with a fairly coarse carborundum stone (say, No. 20) and water. During the rubbing a paste works up, and this is removed by washing. Next, all voids are filled with a mortar (about 2 : 1) made with cement and aggregate of the kind used in making the floor. A carborundum brick is used to work this mortar into the surface. When the surface is smooth and regular it is left to harden for about five days. The rubbing is then repeated, using plenty of water and a finer carborundum brick (say, No. 30 or 36). The paste which is formed should be removed as before.

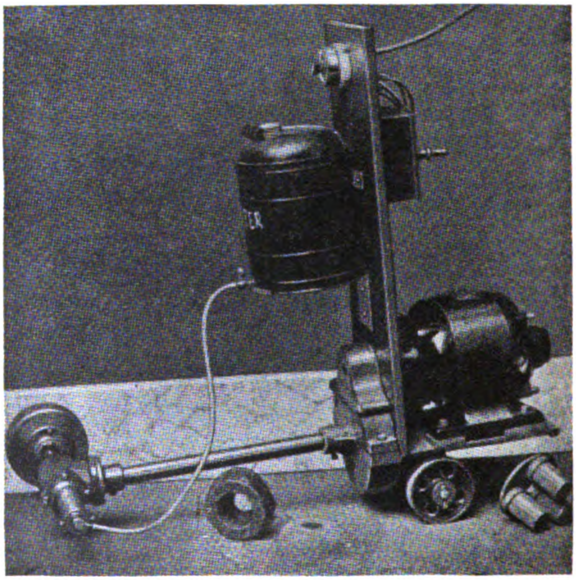


Fig. 3.—Wall Polishing Machine.

Terrazzo Finish.

The following specifications are from a report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete, U.S.A., 1924.

Method 1.—Terrazzo finish shall be made by mixing 1 part of cement, 2½ parts of crushed marble, or other stone or crushed pebbles as may be suitable, and sufficient water to produce a dense concrete. This concrete shall be spread on the base course and worked down to a thickness of 1 in. by patting or rolling and trowelling. The marble shall all pass a ½-in. screen and be free from dust. The surface shall be kept wet for not less than ten days, and after curing shall be rubbed to a plain surface with a stone or surfacing machine.

Method 2.—Terrazzo finish shall be made by mixing 1 part of cement, 2 parts of sand, and sufficient water to produce a plastic mortar, which shall be spread on the base course to a depth of 1 in. Crushed marble, free from dust and passing a ½-in. screen, shall be sprinkled over the surface of the fresh mortar and pressed or rolled in. The surface shall be kept wet for not less than ten days, and after curing shall be rubbed to a plane surface with a stone or surfacing machine.

These specifications are taken from a report of American practice.

The 1-in. thickness seems a trifle excessive; ⅝ in. is fairly usual in this country, and this may be increased to ¾ in. if there is to be a mosaic border in conjunction with the terrazzo.

For vertical work it would be extremely difficult to get a 1-in. thickness to hold up, and the practice in such a case is to make a ⅜-in. or ⅝-in. thickness using a fine aggregate. In this connection it may be mentioned that sometimes an impression of "bigness" is created by the use of fragments of mother-of-pearl in the surface.

The American specifications state that "the surface shall be kept wet for not less than ten days." This seems somewhat drastic, although it may produce a stronger floor than if curing were stopped, say, at the end of three days, as suggested earlier in the article. But in most cases it is a question of money, and if the floor is left for ten days the labour of rubbing will be so great that the job will, in many instances, not be a commercial proposition. The value of curing is, of course, appreciated.

With regard to the use of sand, mentioned in the second specification, it is thought that this material would have a colour and a hardness of its own, and it would perhaps be an improvement to substitute the finest grade of marble chippings (¼ in. down to $\frac{1}{16}$ in.).

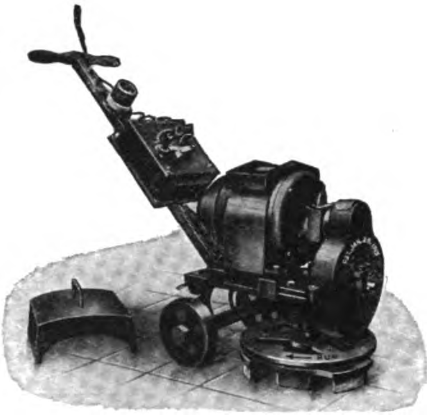


Fig. 4.—Floor Polishing Machine.

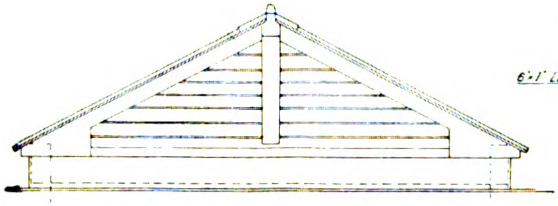
The writer wishes to express his thanks to Mr. R. T. Cooke, chief engineer of Messrs. Constone, Ltd., Leicester, for help in preparation of this article, and also to the Carborundum Co., Ltd., for the loan of *Figs.* 1 and 2, and to Messrs. Hall, Phillipson & Co., Ltd., for *Figs* 3 and 4.

Concrete Products Association.

At an enthusiastic gathering of over a hundred of the leading manufacturers of cast stone and pre-cast concrete, held in London on March 1, it was unanimously agreed to form a Concrete Products Association in this country. The meeting followed a luncheon at the Hotel Victoria arranged by the British Portland Cement Association, who originated the idea of forming the new body and have carried out the preliminary work leading up to this meeting of inauguration.

The primary objects of the new body are the promotion of sales by co-operative propaganda and advertising and the improvement of concrete products generally. It was generally realised by those present that the industry was considerably harmed by the inferior concrete goods occasionally sold by some of the smaller firms who did not specialise in this class of work. There were manufacturers, it was stated, who lacked the necessary experience to produce first-class concrete and made inferior goods, generally as a side-line to another business. It was the products of such firms that got concrete discredited, as it was difficult to induce people to continue to use concrete after they had had unhappy experiences with poor quality products. It is proposed by educational work and the interchange of ideas to raise the standard of concrete products by instructing the smaller manufacturer how to improve his quality. It was generally considered that there would be no danger of loss of business to firms already producing high quality concrete if something were done on these lines, as the general increase in the use of concrete goods that would come about if the public were assured of getting the best would more than counterbalance this and result in more business all round.

A Committee is being formed to draft a set of rules, and all interested are requested to get in touch with the Secretary of the B.P.C.A., 20 Dartmouth Street, Westminster, S.W.1.



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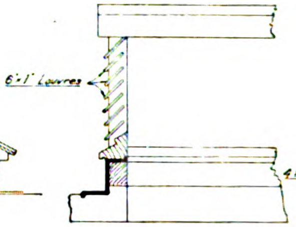
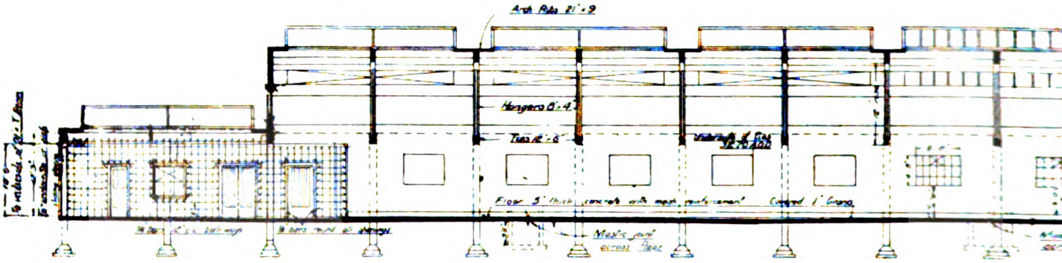


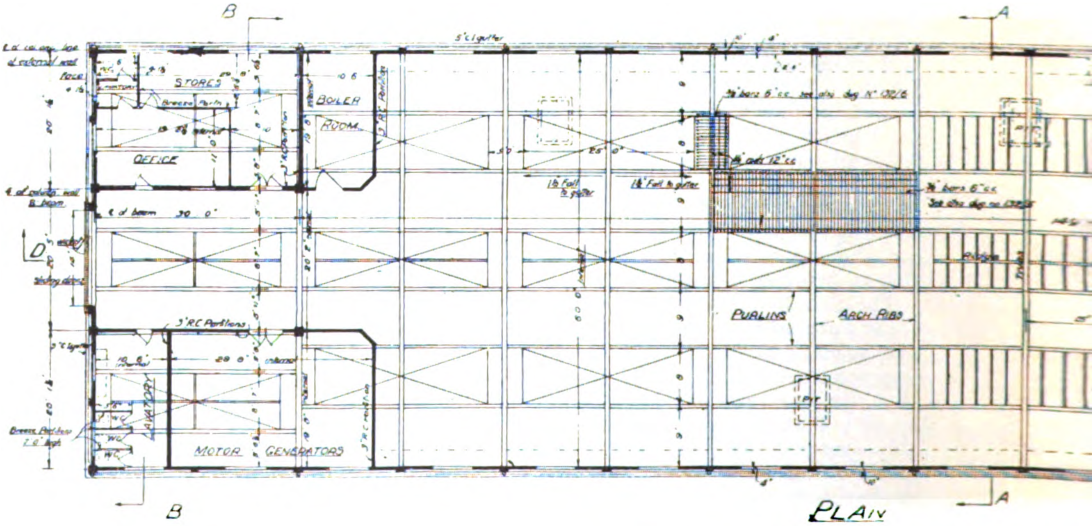
SECTION THRO LOUVRES

6" x 3" Spiggoted & Weathered Cill
4 lbs lead flashing 18" girth


Arch Ribs 21' x 9
Hangers 8' x 4"
Ties 12' x 6
Floor 5" thick concrete with mesh reinforcement. Covered 1" Grano.
Mastic joint across floor
½ bars 12" c.c. both ways
½ bars round all openings

Note. The arch ribs, ties, hangers, purlins, beams & columns to have 1" chamfer thus
Breeze partitions 2½" thick rendered both sides with sirapite

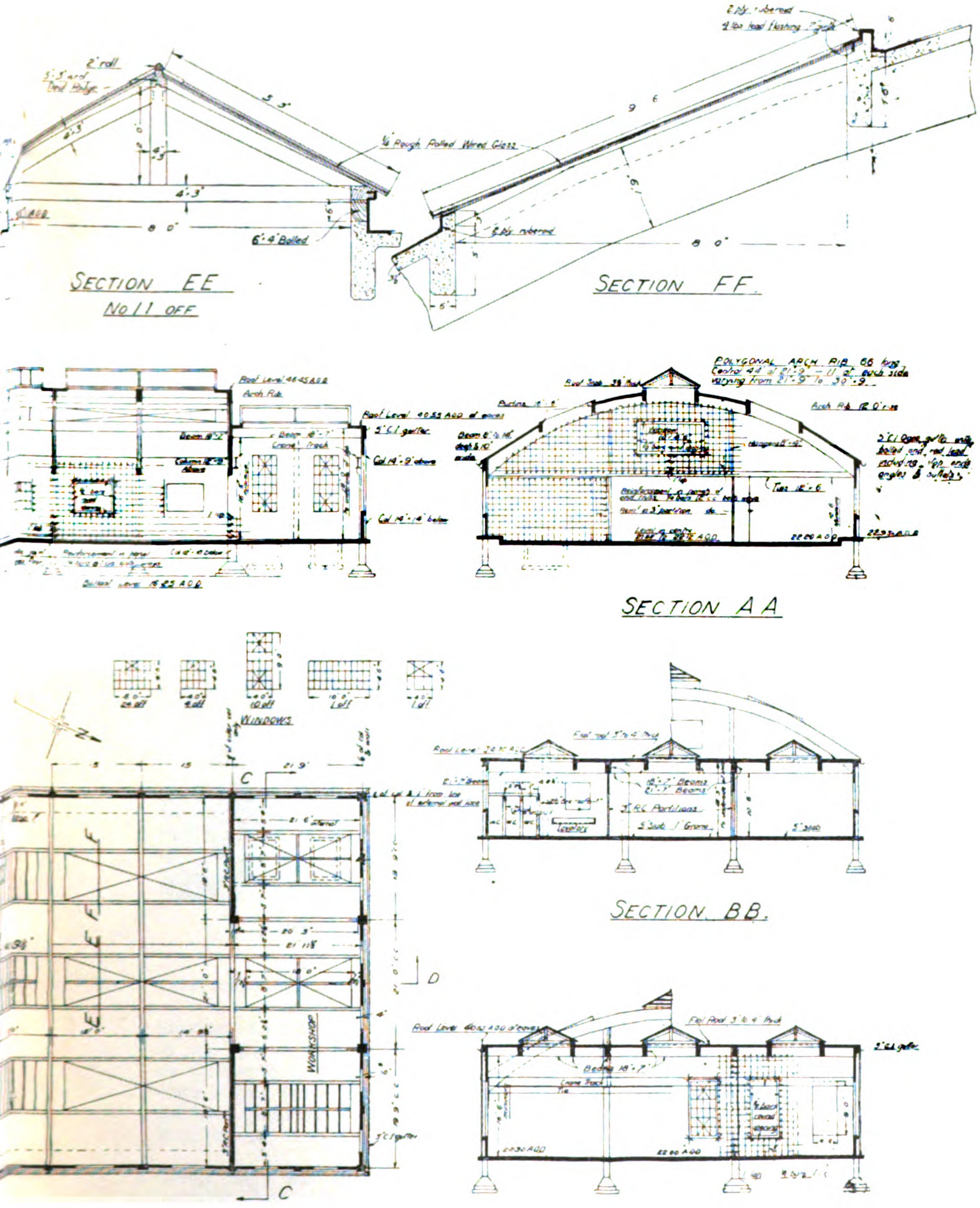
SECTION D D



PLAN

REINFORCED CONCRETE GARA

(For Details of A



ɢE AT HACKNEY. (*See p.* 204.)

rches, *see p.* 218.)

Reinforced Concrete Garage.

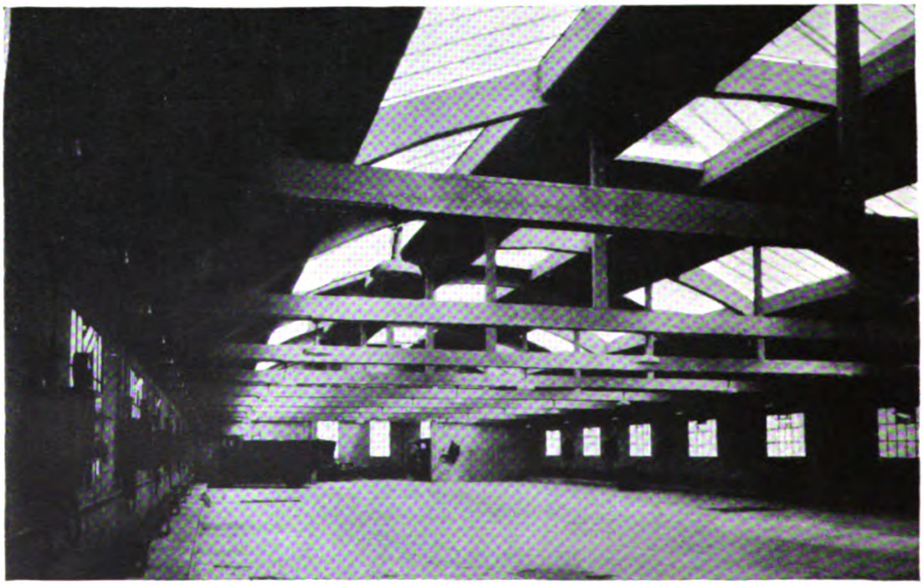
60 FT. SPAN ARCH.

An excellent example of the use and adaptability of reinforced concrete for industrial buildings, and the advantages it offers over other building materials for many purposes, is to be found in the garage built for the Hackney Borough Council in order to accommodate a fleet of electric dust-collector vans and to provide a repair workshop and motor generator room. Mr. Scorgie, the Borough Engineer of Hackney, decided in favour of a reinforced concrete building throughout, and this was erected from plans and specifications prepared by Mr. Alfred S. Grunspan, B.Sc., M.Inst. C.E., of Abbey House, Westminster.

This building is of special interest because of its roof, which consists of a series of arched ribs spanning 60 feet in the clear. The ribs are spaced at 15 ft. centres, and are 21 in. by 9 in. at the crown and 30 in. by 9 in. at the springing.

The columns supporting the arches are only 10 in. by 10 in.; this was made possible by the introduction of a light tie which absorbs the thrust, and eliminates bending in the columns due to thrust action. The tie is treated so that it gives one the impression of being a part of the arch on account of the vertical hangers which connect the tie with the rib.

It is of interest to note that in order to facilitate and cheapen the centering, the ribs have been made polygonal instead of curvilinear; the effect may be seen from the photograph.



Reinforced Concrete Garage at Hackney: Interior View.

The arches carry reinforced concrete purlins formed in such a way as to accommodate glazing bars (covering 40 per cent. of the roof area) and a reinforced concrete slab 3½ in. thick covering the remaining 60 per cent. of the roof area.

The enclosing walls are 4 in. thick, and the sills were cast in one operation with the walls; metal forms were used.

Every member of the building is in reinforced concrete. The 5-in. floor is

Reinforced Concrete Garage at Hackney.

reinforced, the engineer contending that a garage floor is subjected to an upward pressure anywhere along the floor between wheels of vehicles, and for this reason recommends that such floors should be reinforced both at the top and at the bottom of the slab.

The ratio of rise to span of arch is one-fifth, which gives the building a lofty appearance, the headroom at the crown being 22 ft. 6 in. and at the springing 10 ft. 6 in.

An interesting fact is that tenders for the garage with a flat roof with columns at 20 ft. centres by 20 ft. cross centres showed a difference in price of about £300 in favour of the arches.

The total quantity of concrete used was 555 cu. yds. and the total quantity of mild steel round rods amounted to 21 tons—very economical figures for a building of this size.

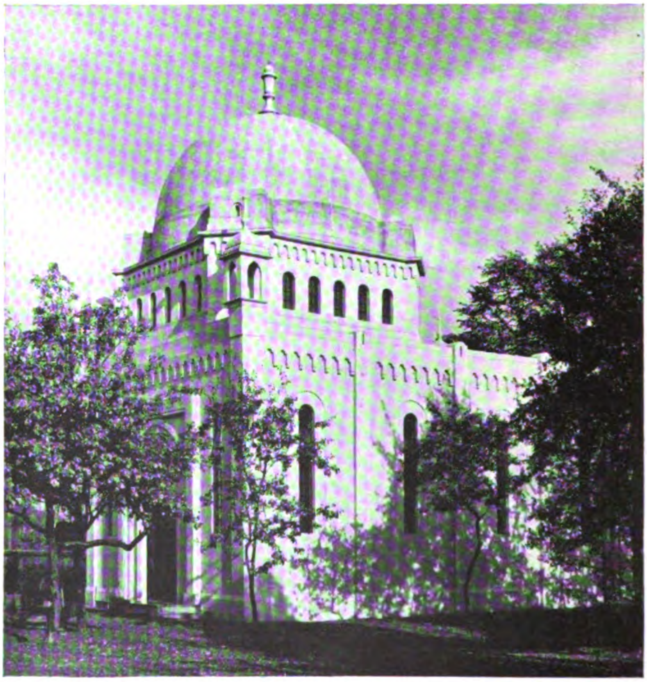
Detail drawings are given on pp. 202–203 and pp. 218–219.

A London Mosque.

The Ahmadiyyah Mosque is the first mosque to be built in London, and was recently completed at Wimbledon. The principal factors to be considered by the architects, Messrs. Thomas Mawson & Sons, were: The design of the building, which should for the time being be a complete unit, and yet permit of extensions on three sides at a future date; to observe as far as possible the traditional style of building in use for mosques in the East, without striking an exotic note in the London suburb in which it was to be erected; while still retaining the traditional style, to adapt the building to the climatic conditions of London and western methods of construction; to secure a true orientation towards Mecca, which is the reason for the rather curious angle at which the building is set on the site. This question of orientation was of the utmost importance, and to ensure its correctness the instruments were specially tested.

The present building is approximately one-quarter of the structure which it is intended to erect at a later date, and when complete will accommodate nearly 1,000 worshippers. The dome and the piers, which are indicated externally, form part of the permanent structure, but the panels between the piers will be removed when the building is extended and the piers will remain as columns to support the roof.

The main structure is a steel frame with curtain walls between the stanchions. The parapet and dome are in concrete cast *in situ*, the thickness of concrete for the dome being only 2½ in., the construction having been carried out without the use of any timber shuttering whatever by employing curved "Self-Sentering" mesh reinforcement. The minarets are also of skeleton steel frame construction, which is bolted to the concrete parapet and then wrapped with "Double Mesh Herringbone" reinforcement to form a base for the "Atlas White" cement plaster finish, which harmonises with the rest of the scheme. The internal floors and ceilings were carried out by using similar methods.



A London Mosque.

Tests on 300-ft. Concrete Chimney.

In "Concrete and Constructional Engineering" for October last we gave particulars of a 300-ft. concrete chimney in course of construction at Duluth, U.S.A., in which apparatus was installed for carrying out tests on temperature variation due to hot gases, stresses due to wind pressure, wind velocities, and deflection of the chimney due to heat and wind pressure.

The chimney was first used in January, 1926, and the tests to date are described in a paper by Mr. Earle D. McKay read at the annual convention of the American Concrete Institute last month. The following abstract is from the copyright proceedings of the Institute.

The chimney was designed to serve five rotary clinker cement kilns, inlets for the gas being placed at two elevations in the chimney shell at right angles to each other. It is estimated that at full operation approximately 500,000 cu. ft. of gas per minute is introduced into the chimney. The temperature in the burning zone of the kilns is approximately 2,800 deg. F.; the gas first passes through a dust-collecting and cooling system, entering the chimney at approximately 500 deg. F.

The sample of the gas was analysed as follows:

		Per cent.
CO_2	(carbon dioxide)	22·2
O	(oxygen)	3·5
CO	(carbon monoxide)	0
N	(nitrogen)	76·3
		100·0

Temperature.

In obtaining the temperature gradient through the chimney shell 30 thermocouples, located at five different elevations were used, and wired to permit the taking of readings with a potentiometer housed at the base of the chimney.

These elevations, with reference to the structural details of the chimney, are as follows: (A) Just below the lower breeching; (B) Just below the upper breeching; (C) Just below the top of the lining; (D) Just above the top of the lining; (E) Near the top of the chimney. The position of these thermocouples with reference to the chimney shell as well as to the ground elevation is shown in detail in *Fig.* 1.

The method of placing the thermocouples was to insert the "hot junction" through a brass sleeve in the concrete until it came in contact with the latter. The next step was to pack the tube with asbestos and seal it. Before readings were started the potentiometer was calibrated to read directly in degrees Fahrenheit.

Temperature readings were begun on January 21, 1926, 28 hours before the gas was turned into the chimney, and were continued hourly for 100 hours. The time required for taking a complete set of readings was approximately 5 minutes. During this first test period the lower breeching was still open, admitting cold air into the chimney. Occasional readings were taken from that time until the middle of March, when work was begun closing the lower breeching. At this point more frequent readings were taken. Several sets of readings were taken during the early summer months. Observations were resumed in the autumn when temperature conditions were fairly stabilised. A special series of readings was taken on December 24 to 27, 1926, to observe the change in conditions caused by a shut down of the mill. The results obtained show the drop in temperature after heat is turned off and a building up again upon resumption of operations.

It was found that the temperature of the concrete and the temperature of the air follow each other closely during the period preceding the admission of the gas into the chimney. The temperature of the concrete follows in general the temperature of the outside air, but the temperature on the inside of the chimney does not increase as rapidly.

Upon admission of the gas the temperatures in the stream rise suddenly 35 deg. Sudden rises in temperature of the gas for short periods of an hour or so produced no apparent increase in the concrete temperature, but for long periods the high temperatures produced some effect.

During March there was a rise in the temperature of the gas within the chimney, due partly to the closing of the south upper breeching and the lower breeching. There is a continued general rise, however, beyond this point which is

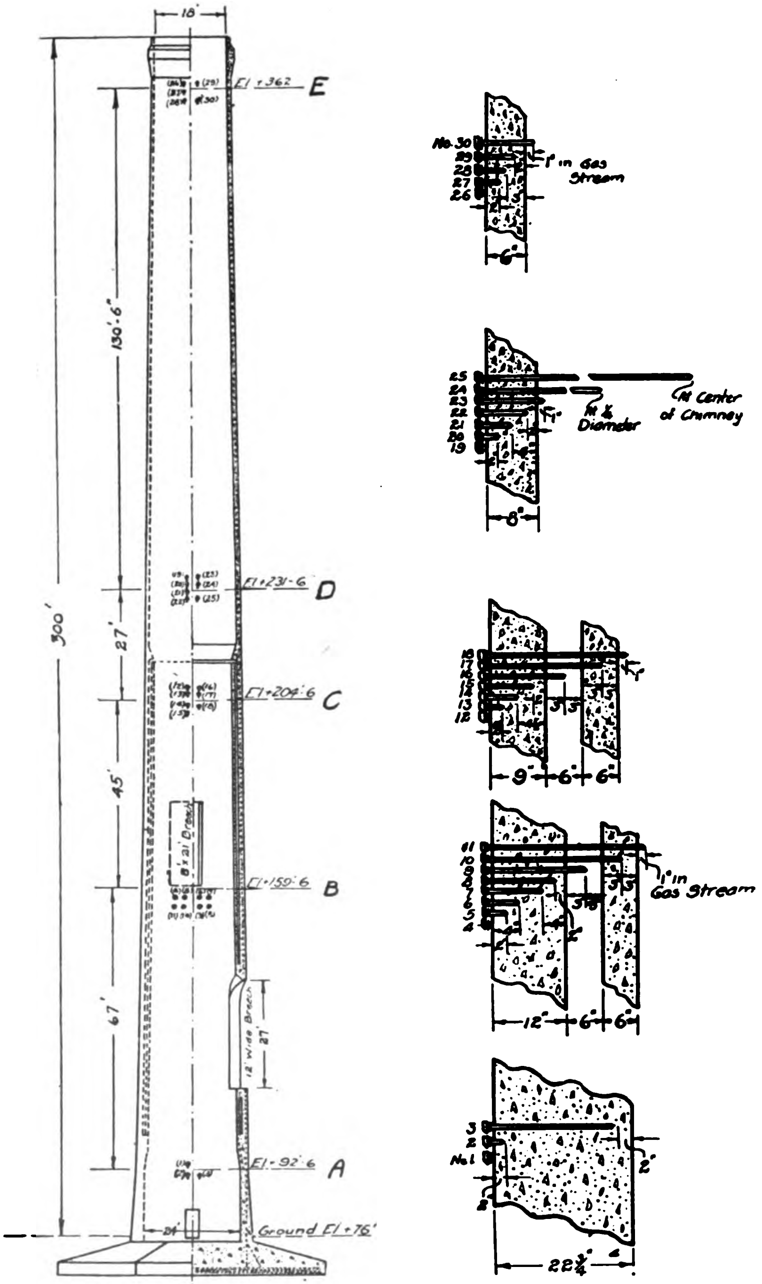


Fig. 1.—Detail of Chimney, Showing Position of Thermocouples.

apparently due to change in the operating conditions, since the outside air shows a general level throughout this period. Here the effect of the increase in temperature of the gas is to produce a warming up of the chimney. A final increase of 60 deg. from March 19 to April 4 produced an increase of about 40 deg. in the centre of the concrete, outside air temperatures on both dates being the same.

The results obtained during the months of October, November and December show, among other things, the remarkable temperature conditions produced by a shut-down of the mill. On October 7 the temperature at the centre of the gas stream was 366 deg., the corresponding temperature of the concrete on the inside of the shell was 150 deg., the temperature of the outside air was 50 deg. One day later the temperature of the gas was 349 deg., the concrete 140 deg., and the air 56 deg. The temperature of the gas 1 in. from the face of the concrete was 54 deg. above the temperature of the concrete at the centre of the shell, and 155 deg. less than the temperature in the centre of the stream. Thus at this point a difference in temperature of 210 deg. between the centre of the gas stream and the centre of the concrete existed. The difference is here more pronounced

TABLE I.

TEMPERATURE READINGS FROM OCTOBER 7 TO NOVEMBER 24, 1926.

Thermo-couple No.	Oct. 7, 1926	Oct. 8 1926		Nov. 3, 1926					Nov. 23, 1926					Nov. 24, 1926	Average all Readings
	3:35 P.M.	11:30 A.M.	3:00 P.M.	9:45 A.M.	12:00 Noon	12:40 P.M.	1:15 P.M.	4:15 P.M.	9:30 A.M.	10:00 A.M.	12:00 Noon	1:30 P.M.	4:15 P.M.	9:00 A.M.	
1......	50	60	63	35	36	36	37	40	28	28	30	31	33	24	38°
2......	70	75	76	42	40	43	45	45	37	40	38	40	40	33	47°
3......	87	85	88	72	71	75	78	81	78	76	77	77	78	73	78°
4......	50	54	55	35	37	37	32	39	25	27	25	30	28	27	36°
5......	85	85	84	51	51	55	57	58	46	48	50	45	50	59	59°
6......	92	91	99	43	53	55	58	46	50	51	46	48	49	60	60°
7......	117	115	117	68	67	72	75	77	70	73	66	62	68	72	80°
8......	128	126	130	132	122	115	97	88	55	57	50	53	53	67	91°
9......	147	144	150	145	137	120	112	100	100	102	95	95	96	98	117°
10......	151	248	237	188	195	187	188	182	183	185	175	177	175	176	189°
11......	281	273	273	218	210	197	193	220	202	202	194	198	194	190	218°
12......	50	56	56	35	38	38	37	41	26	28	25	30	28	37	38°
13......	85	84	84	60	63	65	66	67	51	52	49	53	48	60	63°
14......	92	91	92	66	70	71	72	73	61	60	56	61	57	73	71°
15......	138	128	128	98	102	100	103	103	95	95	88	93	89	93	104°
16......	162	153	154	118	123	123	127	123	116	118	108	115	110	113	126°
17......	252	242	242	217	218	217	215	212	207	208	197	202	197	197	216°
18......	276	267	267	252	253	233	222	250	233	233	228	258	225	220	248°
19.....	49	56	57	35	38	39	38	40	27	28	25	31	30	38	38°
20.....	106	104	04	92	102	95	98	95	77	77	68	75	67	86	89°
21......	150	140	41	135	137	138	137	133	122	122	110	113	107	118	129°
22.....	91	97	99	83	88	87	87	85	67	68	63	63	63	86	81°
23......	208	194	195	197	188	176	172	195	170	170	160	161	156	157	179°
24......	215	217	220	168	170	173	217	250	250	250	270	270	265	250	223°
25......	366	349	343	378	317	247	233	333	295	293	305	305	298	268	309°
26......	43	48	50	27	30	30	32	33	23	25	22	26	26	35	32°
27......	102	102	105	88	92	92	93	90	74	73	68	68	68	88	86°
28......	134	129	132	127	119	120	120	117	102	101	87	90	92	113	113°
29......	155	142	145	133	132	133	130	130	120	120	105	107	108	115	127°
30......	167	155	159	192	142	136	135	145	124	123	110	112	113	123	138°
Outside Temp	63°	67°	67°	15°	15°	15°	15°	15°	23°	23°	23°	23°	23°	22°	29°
Room Temp	68°	70°	70°	65°	65°	65°	65°	65°	30°	30°	30°	30°	30°	32°	51°
Weather	25 mi. N.E. Wind Cl'dy	30 mi N.E. Wind Cloudy		10 mi. N.E. Wind Cloudy					10 mi. N.E Wind Clear					10 mi. N. Wind Clear	
				* Mill closed down 12 Noon to 1:00 P.M.											

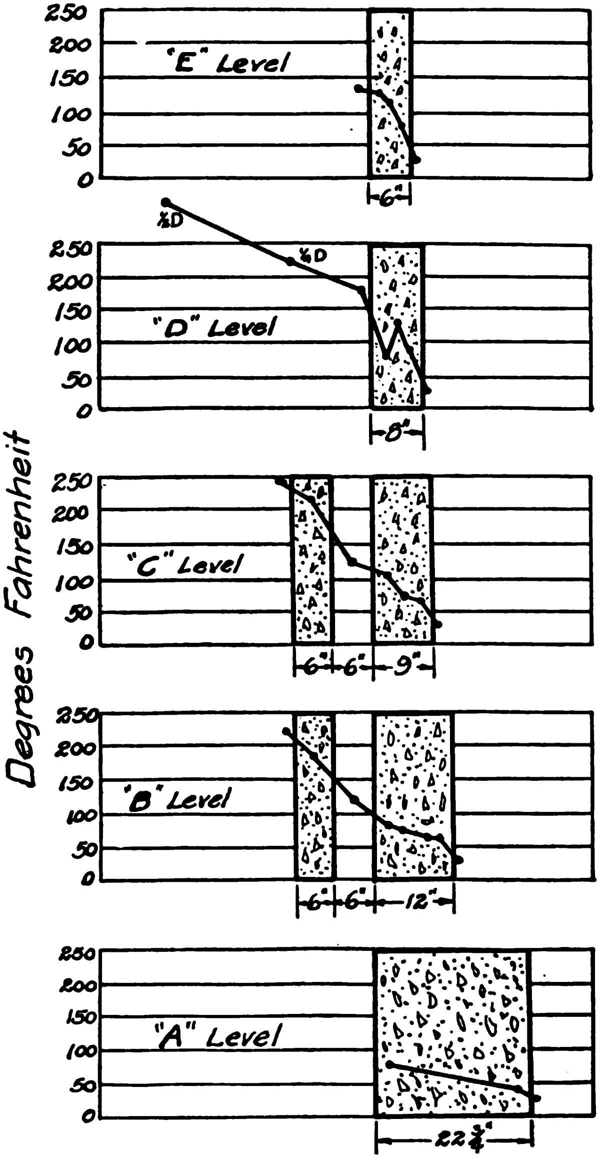


Fig. 2.—Temperatures through Chimney Shell.

TABLE II.

TEMPERATURE DIFFERENCES IN CHIMNEY SHELL.

Thermo-couple	Distance between Couples, in.	Grand Average		Maximum		Minimum	
		Total Temperature Difference	Difference per in.	Total Temperature Difference	Difference per in.	Total Temperature Difference	Difference per in.
5-6	2	4.8	2.4	15	7.5	0	0
6-7	4	20.0	5.0	31	7.7	12	3.0
7-8	2	21.9	11.0	64	32.0	5	2.5
13-14	2½	7.7	3.1	13	5.2	6	2.4
14-15	2½	32.7	13.1	46	18.4	20	8.0
20-21	2	39.8	19.9	45	22.5	32	16.0
21-22	2	48.0	24.0	59	29.5	32	16.0
27-28	1	27.1	27.1	39	39.0	19	19.0
28-29	1	13.7	13.7	21	21.0	2	2.0
2-3	18¾	30.9	1.6	41	2.2	10	0.5
5-8	8	32.1	4.0	81	10.1	0	0
13-15	5	40.5	8 1	53	10.6	33	6.6
20-22	4	8.5	2.1	15	3.7	0	0
27-29	2	41.0	20.5	53	26.5	27	13.5

than at the higher elevations, and the reason may be partially due to the effect of the jog on the inner surface at the top of the lining, which causes a deflection of the gas stream, and partially due to the cold air drawn up through the space between the lining and the shell through the vents at the base of the lining.

Before the mill was shut down on December 24 the temperature of the gas stream was 288 deg., and after this the temperature began to drop rapidly. It continued to fall off for 2 hours, and at 10 hours was still showing a gradual decline. Even at 24 hours the temperature of the gas was still considerably above that of the outside air, but one day later all the readings were practically the same. The maximum drop of temperature of the concrete was 150 deg. and the minimum about 40 deg., which would cause a condition of strain in the shell. The stress in the concrete due to an internal adjustment caused by a difference in temperature of 100 deg., using an average coefficient of expansion of ·000006 at a temperature of 70 deg. and a modulus of elasticity of 5,800,000, as determined from the test cylinders, is much beyond the tensile strength of the concrete if no deflection or distortion is assumed.

Upon resumption of mill operations a condition almost the reverse of that due to closing down is noted.

Table I shows all temperature readings taken during October and November when conditions were fairly stable and the mill was operating under normal load. The averages of all readings are shown in the right-hand column. These results are illustrated graphically in *Fig.* 2. The averages have been plotted on chimney sections at the various levels and the points connected by straight lines. In *Fig.* 3 the same averages have been plotted at the various levels for the height of the chimney. The points occupying the same position relative to the chimney shell have been connected by straight lines.

Table II is the summary of temperature differences in the concrete of the chimney shell made up from the same readings contained in Table I.

It will be seen from these curves that the temperature through the lining and wall varies approximately as a straight line. The average drop in temperature measured for the 6-in. thickness at the " E " level is 20·5 deg. per inch of width, while the maximum is 26·5 deg. It will be noted that this point is above the lining. At " C " level, which is below the top of the lining, the average drop in temperature was 8·1 deg. per inch of width and the maximum 10·6 deg.

Strain Gauge Readings.

In a study of the stresses from strain gauge readings on an exposed concrete structure, a number of factors affecting the deformations must be given consideration, such as temperature, radiant heat, moisture, live and dead load, plastic flow and shrinkage. Measurements taken on the chimney to date have been made to determine the character and amount of stress in the steel due to these factors. These results will be of particular use in the study of the stresses due to wind load, which are to be obtained later with recording instruments. To date no records of deformations due to wind have been obtained. The measured deformations taken with the Berry strain gauge are shown in *Fig.* 4. These results represent the actual deformations in the steel and concrete at the elevations indicated on the drawing. No corrections have been made for temperature or moisture, so that the curves represent the actual movements which have taken place in the gauge lines since the readings were started.

A comparison of the movements of the vertical and the horizontal gauge lines is of particular interest because of the fact that temperature effects, moisture effects, etc., are alike for both readings. Any difference in the deformations measured must, therefore, be accounted for by load

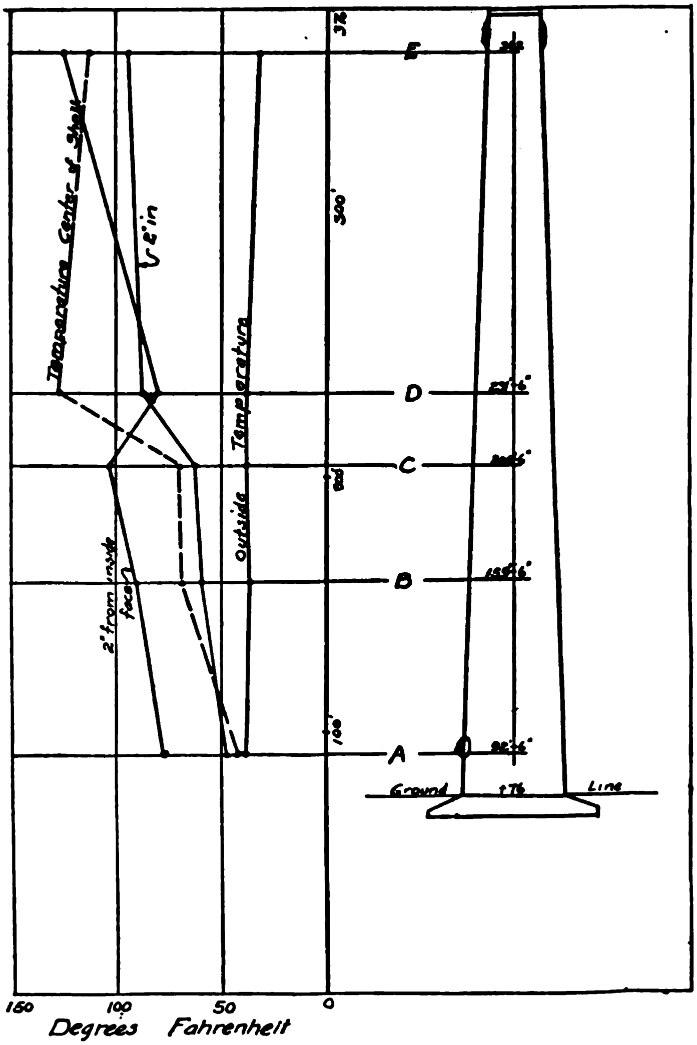


Fig. 3.—Temperature Readings on Vertical Line.

conditions. Shrinkage should be about the same in both directions. In the curves representing the actual movements that have taken place in the gas lines since the initial set of readings, two groups showed both longitudinal and vertical deformations. The difference between the horizontal and vertical movements represents the actual net deformation due primarily to plastic flow of the concrete under load. The dead load on the chimney is the same at this time as at the time readings were started, with the exception of the effect produced by the weight of the intake flues. This load is comparatively very small. Some slight effect may also be due to the fact that there is a difference in the horizontal and vertical reinforcement which would resist the action of shrinkage. This movement is relatively quite small and indicates that the plastic flow under dead load is very slight. This may be partially accounted for by the high elastic properties of the concrete as indicated by the cylinder tests, since values of the modulus of elasticity varied from 5,600,000 to 5,950,000 at the age of 1½ years, and the curves are essentially straight lines up to one-half of the ultimate strength. Beyond this point there is only a slight curvature. From a study of *Fig.* 4 it will be seen that there is a general similarity of the curves throughout. The

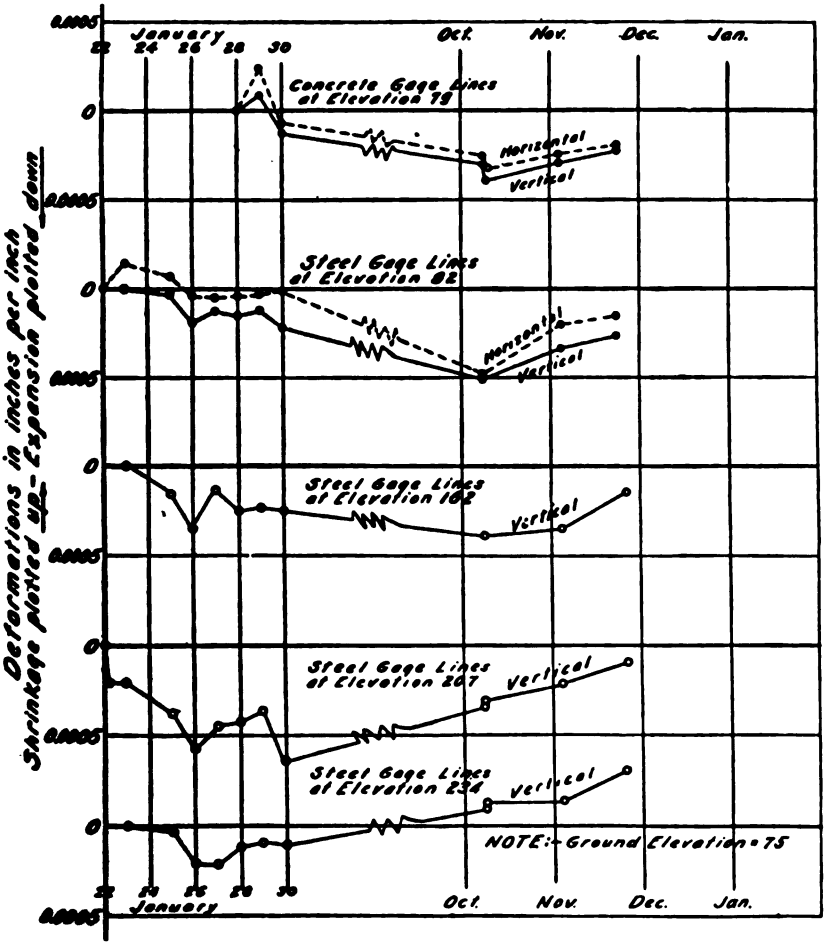


Fig. 4.—Deformation in Chimney.

rise and fall is probably due to seasonal changes in the atmosphere. There has been an expansion in most of the gauge lines from the initial reading in January, 1926, and the present time, but the expansion is becoming less and the movement is now very nearly what it was a year ago. There has been a general shortening of all of the gauge lines during the months of October and November, and it seems probable from the shape of the curve that this shortening will continue for some time. Better comparison can be made when readings are taken at temperatures and general atmospheric conditions corresponding to those existing at the time of initial readings. Since these gauge lines are all located on the outside of the chimney, it will not be possible to make a direct comparison of the internal and external strains. We may conclude, however, that there is some compression in the vertical steel due to shrinkage and plastic flow which must be considered when problems of design are taken up.

Wind Velocity.

Two independent studies of wind velocities were made. In the first a series of pressure pipes leading to manometer tubes were used, and in the second a Burton recording anemometer was employed. Ranges in velocity from 0 to 60 miles per hour were observed at various times.

The pressures in the outrigger impact tubes were considerably less than was expected. The reason for this is not yet known, and further tests of the apparatus will be necessary before this condition can be explained.

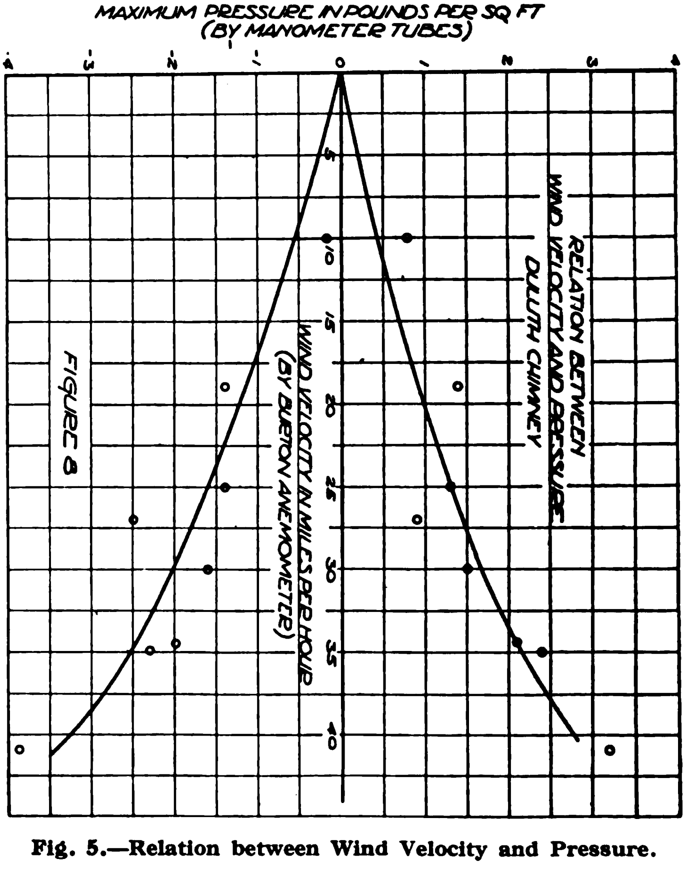


Fig. 5.—Relation between Wind Velocity and Pressure.

TABLE III.

TABULATION OF WIND PRESSURE READINGS: REDUCED TO VERTICAL INCHES OF WATER.

No. of Tube	Dec. 15, 1926 2:05 P.M.	Dec. 15, 1926 2:30 P.M.	Dec. 15, 1926 1:55 P.M.	Oct. 7, 1926 3:55 P.M.	Dec. 14, 1926 3:45 P.M.	Oct. 8, 1926 4:00 P.M.	Dec. 14, 1926 4:00 P.M.	Oct. 8, 1926 10.00 A.M.
1	−.225	−.173	−.094	−.163	−.244	−.134	−.134	−.005
2	−.379	−.398	−.268	−.178	−.479	−.138	−.258	−.034
3	−.515	−.445	−.293	−.135	−.394	−.094	−.203	−.021
4	−.559	−.237	−.118	−.157	−.138	−.118	−.058	−.013
5	−.046	+.220	+.230	−.116	+.158	−.073	+.210	+.023
6	+.369	+.449	+.389	−.159	+.165	−.099	+.260	−.040
7	+.621	+.445	+.405	−.147	+.070	−.098	+.245	0
8	+.480	+.091	+.081	−.137	−.177	−.087	+.051	0
9	−.020	−.358	−.258	−.174	−.480	−.178	−.208	−.024
10	−.568	−.568	−.376	−.306	−.548	−.266	−.246	0
11	−.746	−.324	−.186	−.275	−.315	−.146	−.087	+.010
12	−.388	−.238	−.168	−.088	−.334	+.050	−.098	+.005
13	−.346	−.228	−.168	+.109	−.307	+.191	−.098	+.150
14	−.346	−.216	−.167	+.286	−.296	+.246	−.097	+.035
15	....	....	....	+.151	....	+.172	....	+.015
16	−.305	−.196	−.137	+.110	−.315	−.078	−.098	0
17	−.336	−.246	−.166	−.166	−.286	−.206	−.086	−.022
18	−.315	−.226	−.145	−.077	−.276	−.067	−.067	−.010
Anemometer Reading, miles per hour	42	35	34	30	27	25	19	10

Wind Pressures.

Wind pressures were read by means of impact pressure tubes at 18 points equidistant around the chimney at 190 ft. above ground level. The openings into the tube are flush with the face of the chimney and transmit the pressure in separate ⅜-in. pipes to the base where the pressures are read. Glass tubes filled with coloured liquid are placed side by side on a tilting table. The table is so

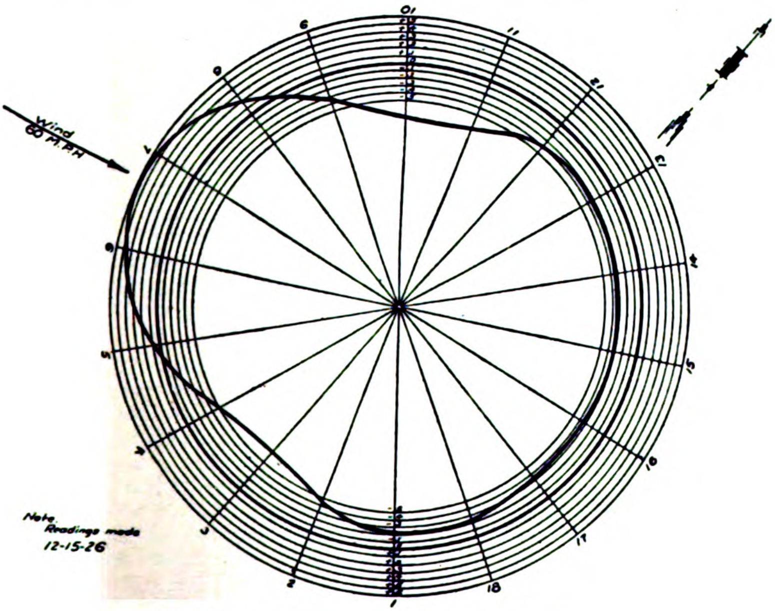


Fig. 6.—Distribution of Wind Stresses.

arranged that the angle the tubes make with the horizontal can be varied so as to give any multiplication of the readings desired. So far all readings have been taken with the manometer table inclined at a slope of 1 to 10, which multiplies the readings by 10. The results of a group of the readings are shown in Table III. The maximum pressures obtained from these readings are plotted in *Fig.* 5. The curve represents the average maximum pressure for velocities up to 42 miles per hour. Since these readings are taken with two different types of instruments, in which experimental errors may be additive, the points are somewhat at variance. The curves indicate, however, an increase in the positive and negative pressures as the wind velocity increases up to 40 miles per hour. Sufficient data have not been obtained beyond this velocity to warrant extending the curves.

Fig. 6 represents the distribution of pressures around the stack. It can be seen that the pressure is positive on three-fifths of the projected circumference on the windward side of the stack, and negative on the balance of this side. It is negative throughout on the leeward side. The maximum positive pressure occurs at the point directly into the wind and the maximum negative pressure occurs also on the windward side of approximately 70 deg. around the stack on either side of the maximum positive pressure.

Deflections.

An attempt was made to measure the deflection of the chimney with the apparatus proposed by the committee. It was found, however, that the vibration of the concrete base supporting the telescope, due to the operation of machinery in this vicinity, was so great as to make accurate observations impossible.

International Congress for Testing Materials.

At a joint meeting of the Dutch and Swiss Associations for Testing Materials, held at Zurich last October, it was decided to organise an International Congress for Testing Materials, to be held at Amsterdam from September 12 to 17, 1927. This movement aims at the continuation of the work of the old International Association for Testing Materials, which was formally wound up in 1923. No new international association has been formed, but it is understood that representatives of certain countries may wish to discuss at the Amsterdam Congress the possibility of bringing a new International Testing Association into being.

The Congress at Amsterdam is, we are informed, apparently receiving strong support by other countries, and is likely to be numerously attended by representatives from France, Germany, the United States, Belgium, Holland, Sweden, Denmark, and Switzerland. It is also likely that the United Kingdom will be represented by delegates from the principal laboratories and institutions interested in the testing of materials. Those wishing to attend the Congress should communicate with Mr. P. F. Van der Wallen, Office of International Testing Congress, Valckenierstraat 2, Amsterdam.

Book Reviews.

Marine Works. By Ernest Latham.

223 pp. 86 illustrations. Price 16*s*. nett. (London: Crosby, Lockwood & Son.)

THE reader expecting to find a textbook on marine structures such as piers, wharves, docks, etc., will perhaps be disappointed in this work, inasmuch as the author has no such ambitious intentions, but assumes that all technicalities of this description are known to the reader. He gives, however, a great deal of valuable information, some of which has been published before in the form of papers or articles in technical journals, and is now collected in book form. This is sometimes manifested in repetition or overlapping, but in all of it the author's extensive experience is felt as a solid backing.

The book deals with the problems of scour and coast defence, the conservancy of marsh lands, and navigable rivers, and has some interesting chapters on the maintenance and salvage of maritime works. The author's experience leads him to some interesting conclusions with regard to the relative cost of marine structures, and most reinforced concrete engineers will agree with him that the initial cost of a timber jetty is practically the same as that of a reinforced concrete one. They may perhaps not be quite so willing to agree with the author in his statement that the maintenance and repair of a concrete jetty is much more difficult and costly than that of the timber jetty. The bugbear of slowness in execution which is, as usual, mentioned as a factor against the use of reinforced concrete, may surely by now be considered as fading into evanescence with the presence of rapid hardening cement on the market, and with the tendency to eliminate bracing and other tide work by suitable design.

The chapter on dredging is very instructive, and reveals some interesting facts as to costs per cubic yard, which are stated to vary between 10*s*. 6*d*. and "½*d*.," the latter figure obviously being a misprint for 1*s*. 8*d*.; the author gives some formulæ for determining the volume of solid per cubic foot of sludge, and goes at great length into the question of establishing a basis of equitable payment to the dredging contractor, a point of controversy in nearly every dredging contract.

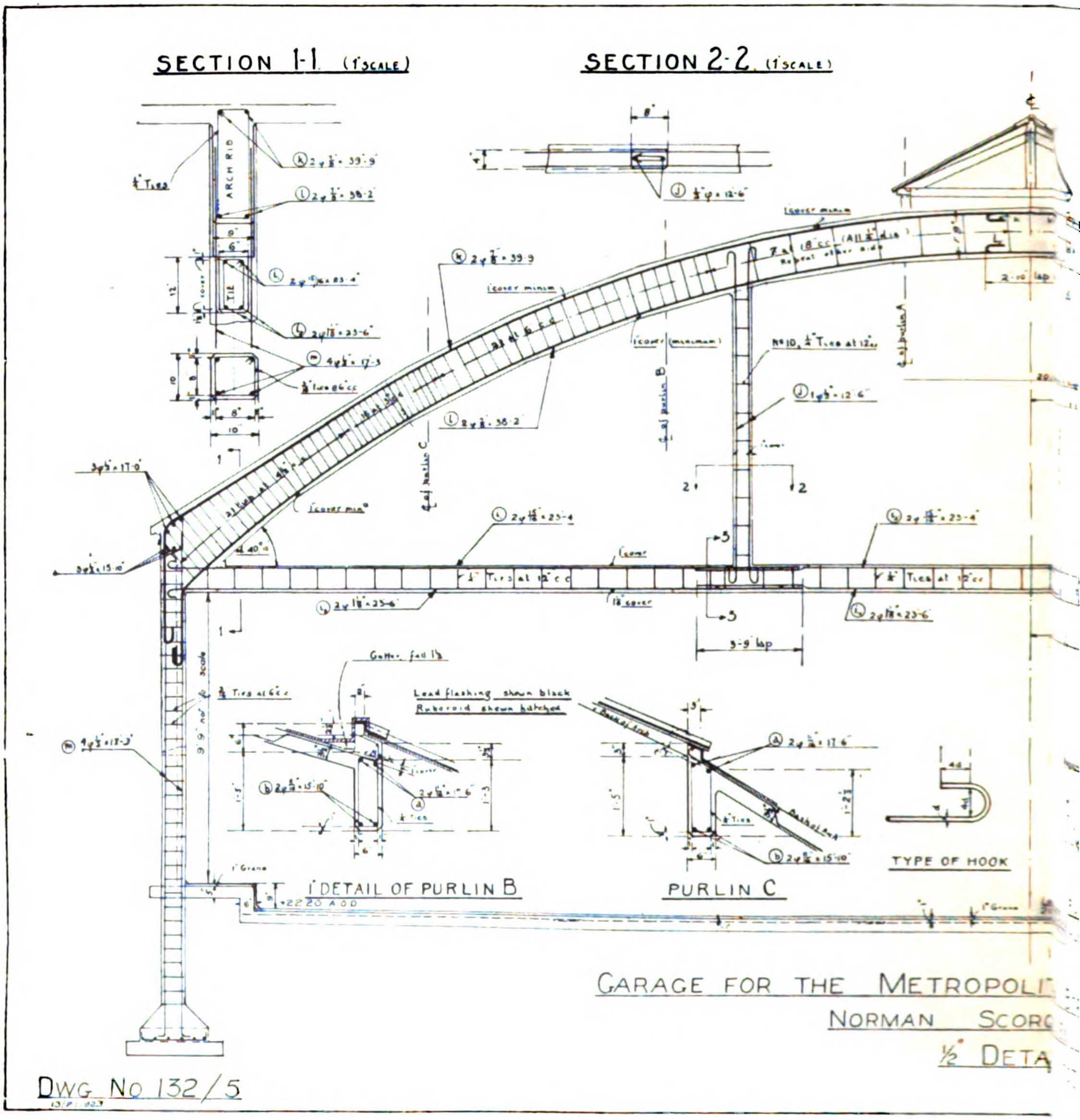
The most valuable part of the book is, however, contained in an appendix on the legal aspects of maritime engineering, an aspect which is very often overlooked by the engineer who has to deal with the erection or demolition of marine structures, usually with the attendant question of dredging, and who is mainly intent upon the purely constructional side of the work. The appendix gives in tabular form a list of cases within recent years of general interest to engineers, wharf and land owners, shipping companies, contractors, and others, and finishes by giving a few notes on the Land Drainage Acts examined from the engineer's standpoint.

Altogether the book is a very useful addition to the library of engineers who are called upon to deal with marine works of any description.—R. N. S.

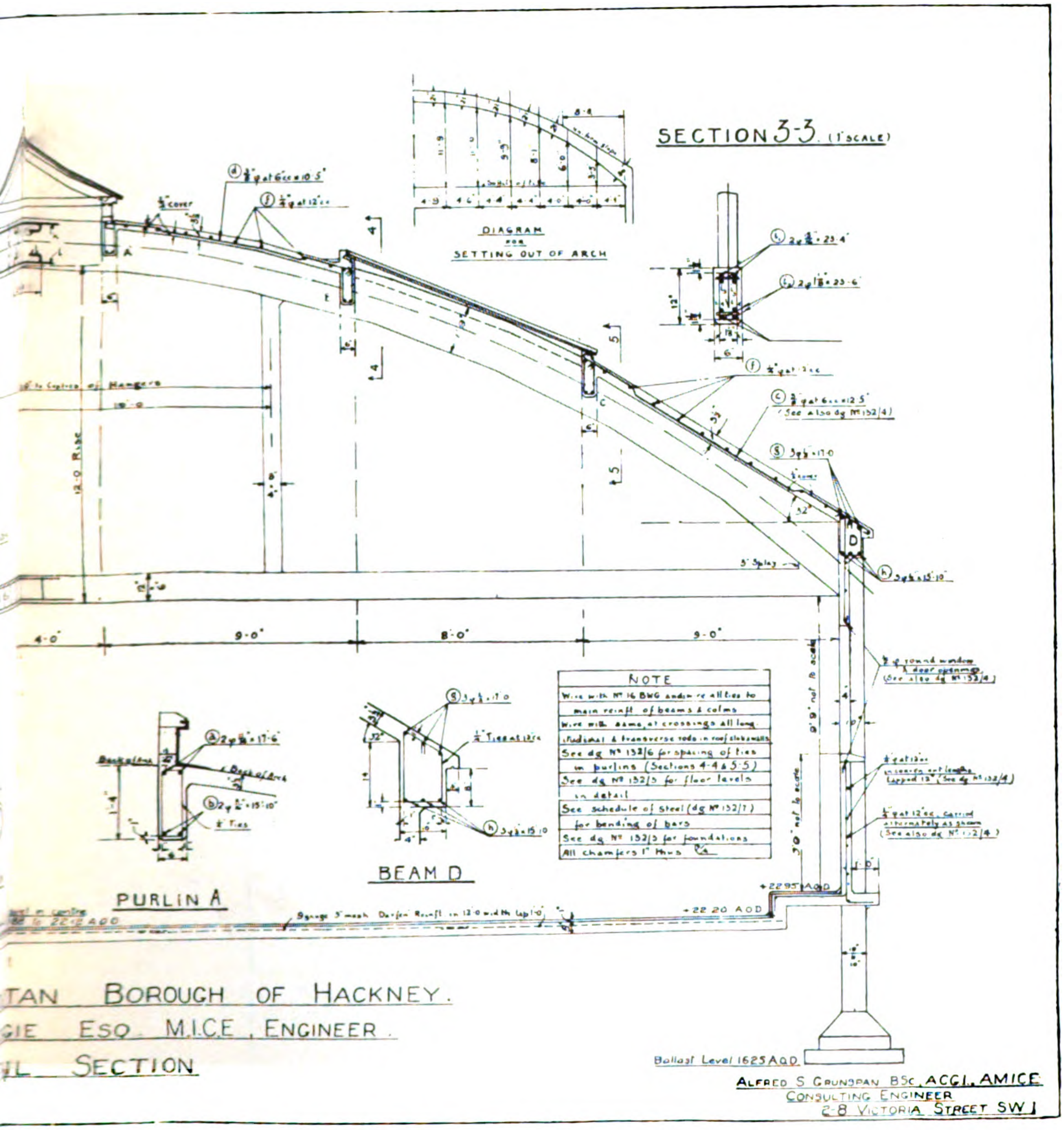
Concrete Practice. By George A. Hool and H. E. Pulver.

London: McGraw-Hill Publishing Co., Ltd. Price 17*s*. 6*d*. net.

THIS book is primarily intended for the use of students, but it should also be valuable to engineers and others engaged in concrete work. No attempt is made to deal with reinforced concrete design. The object of the authors is to cover the whole field of the use of concrete, particular attention being given to proportioning, consistency, and placing. The first section deals with the fundamental considerations of concrete and its uses; then follow sections on Proportioning, Mixing and Placing; Contracts, Specifications and Plans; Estimating; Laboratory Methods and Field Work; while appendices give standard specifications for testing cement and concrete, grading and proportioning, etc. Each subject is dealt with as a "job," of which there are 107, and at the end of each is a set of exercises dealing with that particular "job" for the use of instructors and students.



REINFORCED CONCRETE GAR



NOTE

Wire with Nº 16 BWG and secure all ties to main reinft of beams & colms

Wire with same, at crossings all longitudinal & transverse rods in roof slabs walls

See dg Nº 132/6 for spacing of ties in purlins (Sections 4·4 & 5·5)

See dg Nº 132/3 for floor levels in detail

See schedule of Steel (dg Nº 132/7) for bending of bars

See dg Nº 132/3 for foundations

All chamfers 1" thus

ALFRED S GRUNSPAN BSc, ACGI, AMICE
CONSULTING ENGINEER
2-8 VICTORIA STREET SW 1

AGE AT HACKNEY. (*See p.* 204.)

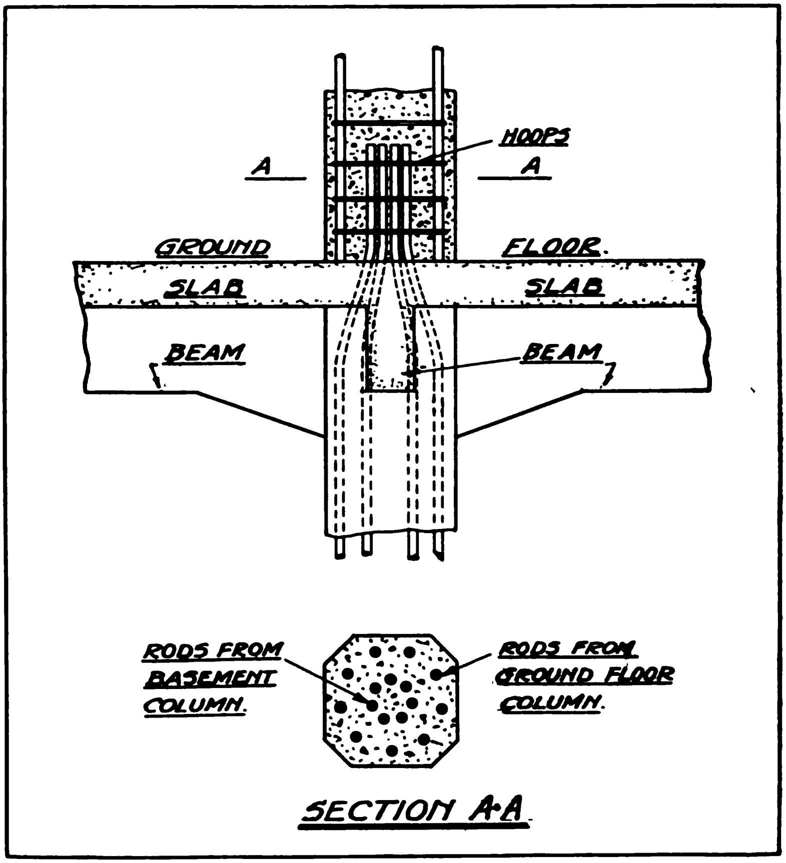
Questions and Answers relating to Reinforced Concrete.

Readers are cordially invited to send in questions relating to concrete. These questions will be replied to by an expert, and, as far as possible, answered at once direct and subsequently published where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—Ed.

Reinforcement of Column.

Question.—The accompanying sketch shows the upper and lower lengths of a reinforced concrete column recently executed and passed by an engineer to a well-known concrete engineering firm. The rods from the lower column are all bunched together in the centre as shown at the junction of the upper and lower lengths of column. The reinforcement to the upper column is placed as shown, some distance away. I refuse to be persuaded that the load carried by the upper reinforcement can be transferred to the lower reinforcement, and I contend that what will actually take place is that the concrete at the base of the first to ground floor columns will be overloaded, because the upper steel has no bond with the lower column and therefore cannot pass its load on to the lower column steel. I have never seen a splice made in this manner and approved by an engineer, and I should be glad of your views.

My opinion is that the detail is thoroughly bad and should not be allowed



unless a steel plate is inserted under the upper rods to take the load.

The column is an interior one, the spans are equal, and the bending, if any, could be ignored.—F. G. H.

Norwich.

ANSWER.—This subject is one of the problems which do not appear to be dealt with at all thoroughly in standard text-books, probably owing to the complexity of the subject and to the space that would be required to treat it fully.

Even assuming that all bending can be ignored, the connection illustrated in the sketch would not be termed a good one. Considerable care is necessary when designing such a connection since the load on the upper bars can only be transferred to the lower bars through the concrete. The stress produced in the concrete by this is additional to the normal working stress, and thus it is desirable to keep it as low as possible.

In a well-designed joint, bars, equal in number to those in the upper column, would be run up from the lower column for a distance great enough to give the desired lap. Further, each lower bar would be next to an upper bar so that they could be wired together. This wiring is not always done, but it is advisable. To do this, a slight offset in the lower bars is usually necessary, and in the case of a column which is reduced in size above the floor level the offset would probably be greater.

Good practice would limit the slope of such an offset to 30 degrees with the vertical. It is also recommended not to begin the offset for at least six inches below the bottom of the lap, the bottom of the upper rods being at floor level.

Under certain conditions the use of a steel plate might improve matters, but unless it were designed and placed carefully the joint would probably be worse than if no plate were present.

Tank Cover.

QUESTION.—I enclose a design for a flat-slab tank cover, and should be glad to have your opinion as to its suitability for the purpose.—L. G., Malta.

ANSWER.—We suggest that it would be better to adopt the usual type of beam and slab flooring in preference to the suggested mushroom type, which is not very suitable for the purpose. The beamless floor presupposes fairly heavy superloads to be economically suitable, and the comparatively great slab thickness required minimises the effect of any inaccuracies in placing the steel, which latter operation must be executed with much greater care than in the usual beam and slab design, and in the case of a thin slab calls for a degree of skilled labour which is not usually found in this country. We should hardly think conditions in Malta would be so much more favourable as to warrant the use of this design, although on paper it may look very attractive. We note our correspondent works to sixteenths of an inch in his concrete thicknesses, while in this country we might be glad always to get an accuracy of a quarter of an inch; and although he may possibly have his concrete work done with this degree of accuracy, we feel sure that the placing of the reinforcement will never be correct to the same degree when taking all the practical elements of the operation into consideration. In such a finely-cut design a small displacement of the steel during concreting would result in greatly increased stresses.

Our correspondent suggests supporting the slab at the ends on brick corbels. This, however, is not a good practice, as the whole theory of mushroom design is based on the relativity of minute deflections; a brick corbel would deflect in quite another ratio than a concrete column and head, and should be substituted by the latter.

Practical Opinions on New "Formwork" Book.

WE give below some opinions we have received from purchasers of our latest book, " Design and Construction of Formwork for Concrete Structures," * by A. E. Wynn, B.Sc., A.M.Am.Inst.C.E., of which a large number have already been sold. The book comprises 320 pages, and is copiously illustrated with drawings and photographs. Designs are given for formwork for every type of concrete structure, from simple footings to arch bridges, and many tables from which sizes of timber for any shuttering purpose may be seen at a glance. Costing data is given for every type of work, and chapters are included on Flat Slab Construction, Steel Forms, etc. The price of the book is 20s. (by post 9*d*. extra).

From the

British Reinforced Concrete Engineering Co., Ltd.

This is the most comprehensive treatise on the subject we have seen. For the first time it brings into one volume the existing information on a subject which is becoming of increasing importance to all who are interested in obtaining efficiency and economy in concrete design and construction.

From

Robert Colhoun, Builder, Londonderry.

This book should be in the hands of every builder, and should be a text-book in technical schools. I have received much useful information from it, which has helped me to simplify the construction of shoring and temporary work. I have shown it to one of my principal foremen, who also appreciates it. The section dealing with costs is quite within the experience of actual fact, and is a useful guide.

From

Comben & Wakeling, Ltd., Builders, Wembley.

We consider this to be a very useful and comprehensive work of reference, which fills a long-felt want.

From

Mr. David A. Donald, Chief Engineer, Glasgow-Edinburgh Road.

The tables giving dimensions of formwork members for many usual purposes are very useful, especially to those who have had no training in mathematics.

From

Galbraith Bros., Ltd., Builders, London.

We consider this book absolutely essential to any engineer or contractor engaged on the erection of concrete work. The design tables are invaluable, and the photographs extremely clear and practical. The data and labour costs are of great value in estimating. We consider the price extremely reasonable.

From the Bulletin of the

Indented Bar & Concrete Engineering Co., Ltd.

This book should be of inestimable value to designers and contractors. In addition to its essentially practical nature, it establishes the subject of formwork on a scientific basis. It covers the entire field of construction, is copiously illustrated, and provided with folders and tables which give at a glance the scantlings required and their mode of use. The author deserves the sincere gratitude of the entire building industry for the compilation of an exceptionally thorough treatise. It is one of those books no builder can afford to be without.

From

J. B. Johnson & Co., Ltd., Builders, Liverpool.

This is a very comprehensive work, which should be studied by all concrete contractors. The sections devoted to the theory and design and the strength of centering are especially valuable. The tables are very simple and the illustrations clear.

From

The Reinforced Concrete Construction Co., Manchester.

The book particularly appeals to us for its examples of shuttering and centering for the heavier class of work, such as bridges.

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* Published by Concrete Publications, Ltd., 20 Dartmouth Street, Westminster, London, S.W.1.

From

Mark Round & Sons, Limited, Builders, Dudley.

We feel sure the knowledge gained from this book will prove extremely useful.

From

Joseph Wheater, Ltd., Builders, Bradford.

Undoubtedly this is a very valuable publication, with extremely interesting and useful information ; it should be in the hands of every architect, engineer, and contractor, and especially foremen in the employ of contractors specialising in concrete work.

From

Watkin Williams & Sons, Builders, Cardiff.

We should like to say, for the sake of all others engaged in carrying out concrete work, that in our opinion upon studying this book they will come to the same conclusion as us, namely, that it is very valuable and useful in many ways. We believe this book will help to reduce expenditure on concrete work.

From

Yorkshire Hennebique Contracting Co., Ltd., Dundee.

This book is very useful indeed, especially to contractors, engineers and foremen.

From the

Engineer & Surveyor to the Leadgate U.D.C.

I can honestly say that this book appeals to me as being a most useful book for anyone engaged on concrete construction. To municipal engineers who have to construct their works by unemployed labour it will prove an excellent reference, and will result in a saving of time and worry.—VIVIAN J. HUNTER, P.A.S.I.

From the

Borough Engineer and Surveyor of Taunton.

This book is an extremely interesting one, and supplies a long-felt want to any engineer who has to deal with concrete construction. The illustrations are set out in an extremely clear and simple manner, and the photographs showing methods of shuttering are also of great value. There is no doubt the book will be of the utmost value to engineers who have to formulate schemes at very short notice.—IVOR F. SHELLARD, A.M.Inst. C.E.

One from America.

There is a crying need for a comprehensive work on the subject of forms, and I am sure Mr. Wynn's book will be enthusiastically received.—O. A. STELLER, Editor, " Concrete," Chicago.

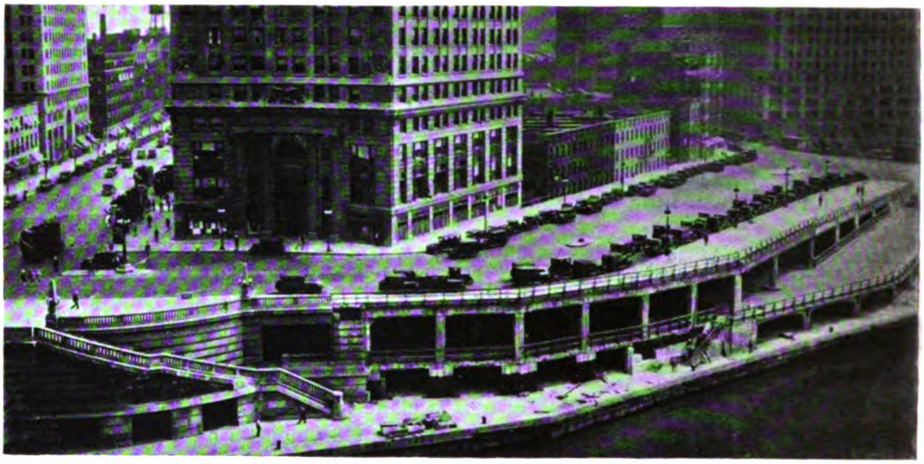
Contents of " Design and Construction of Formwork for Concrete Structures."

CHAPTER I.—FORM BUILDING IN GENERAL.
CHAPTER II.—MATERIALS, LOADS, PRESSURES AND STRESSES.
CHAPTER III.—THEORETICAL DESIGN OF FORMS.
CHAPTER IV.—DESIGN TABLES.
CHAPTER V.—DESIGN PROBLEMS.
CHAPTER VI.—DETAIL CONSTRUCTION OF FOOTING FORMS.
CHAPTER VII.—DETAIL CONSTRUCTION OF COLUMN FORMS.
CHAPTER VIII.—WALL FORMS.
CHAPTER IX.—DETAIL CONSTRUCTION OF BEAM AND GIRDER FLOOR FORMS.
CHAPTER X.—FORMS FOR RIB FLOORS AND STRUCTURAL STEEL FIREPROOFING.
CHAPTER XI.—MISCELLANEOUS FORMS IN BUILDING CONSTRUCTION.
CHAPTER XII.—FORMS FOR FLAT SLAB CONSTRUCTION.
CHAPTER XIII.—FORMS FOR CONDUITS, SEWERS AND CULVERTS.
CHAPTER XIV.—FORMS FOR TANKS, SILOS, BINS AND STANDPIPES.
CHAPTER XV.—FORMS FOR DAMS, PIERS AND HEAVY WALLS.
CHAPTER XVI.—STEEL FORMS IN BUILDING AND WALL CONSTRUCTION.
CHAPTER XVII.—STEEL FORMS FOR CURVED SURFACES.
CHAPTER XVIII.—ARCH FALSEWORK.
CHAPTER XIX.—OTHER BRIDGE FORMS.
CHAPTER XX.—PATENT DEVICES.
CHAPTER XXI.—PLANNING THE WORK.

TABLES.

1. Maximum span of floor sheathing for various thicknesses of slab.
2. Maximum span of wall sheathing for various heights of wall.
3. Maximum span of column sheathing for various heights of column.
4. Maximum spacing of floor joists for various spans and thicknesses of slab.
5. Maximum concentrated loads carried by ledgers and walls for various spans and spacing of loads.
6–9. Spacing of column yokes for various sizes and heights of column.
10. Maximum spacing of wales and wall ties for various sizes of studs and heights of wall.
11. Safe loads on posts.

271 Illustrations.



A Double-Deck Road.

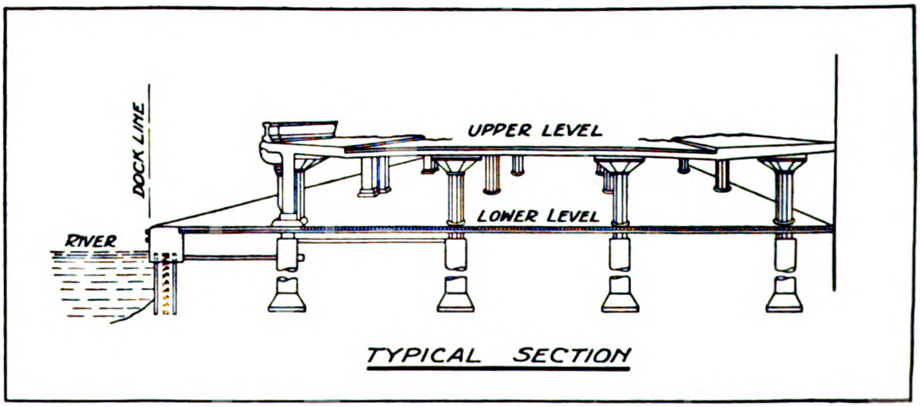
A Double-deck Road.

A NEW municipal improvement in Chicago takes the form of a double-deck street along the south bank of the Chicago river and in the heart of the city. The improvement extends for a distance of a little over a mile, following the course of the river. The structure is of reinforced concrete with a drop-panel flat-slab design for the upper deck, except at the bridge approach intersections where it was necessary to resort to beam and girder design. The upper deck is 13½ in. thick.

The lower level is to be used entirely for heavy commercial traffic and the upper level for motor-cars. On the lower level there is a dock floor of reinforced concrete laid on a sand fill. The total width of the lower level from the dock line to the building line is 135 ft., and the width of the upper level from the hand-rail to the building line 114 ft., with a roadway 72 ft. wide.

The traffic on the lower level is divided into two streams by intervening columns. Electric lights are set in the columns in such a manner that the beam of light comes from behind the driver and does not interfere with the vision of drivers approaching from the opposite direction on the other side.

The work was done under the direction of the Board of Local Improvements. The contractors for most of the work were the Mid-Continent Construction Co.



TYPICAL SECTION

New Type of Gravel Washer.

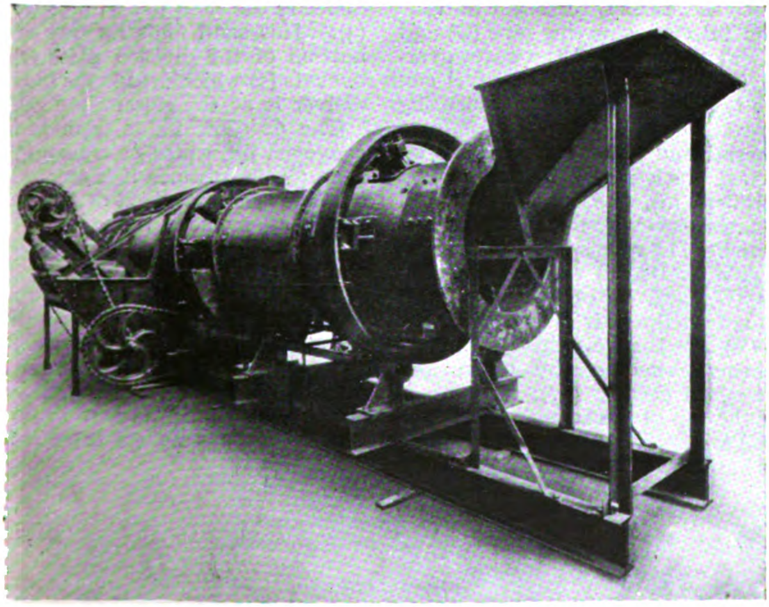
We illustrate below a new type of gravel washer, with screens and sand-and-water separator, recently constructed to order under Southall's patents by Messrs. Hardy & Padmore, Ltd., the well-known specialists in this kind of plant, of Worcester. It is claimed of this type of washer that, in addition to efficient washing, it uses a minimum of water and gives a very large output for its size.

The various processes are illustrated in the diagram. The gravel to be washed is fed into the hopper (A) regularly, at, say, intervals of six seconds, each delivery weighing about one six-hundredth part of the total weight the washer is designed to handle per hour. The grating (B) in the hopper (A) serves to prevent over-large stones going into the washer.

The gravel falls from the hopper (A) into the first conical barrel compartment (C) in which it is well turned over as the slope of the barrel travels it [illegible] in the direction indicated by the arrow (D), during which process it is freed from the majority of the dirt by help of the water it encounters flowing in the opposite direction as indicated by the arrow (E) towards the overflow at (F), carrying with it the dirt washed out of the gravel. The gravel when it reaches the lifting shelves (G) is carried up by them and dropped on to the transfer chute (H) revolving with the barrel, which shoots the gravel into the second conical compartment (J), in which it goes through the same treatment as in compartment (C), but in cleaner water, which therefore has a considerably increased cleansing action on the gravel.

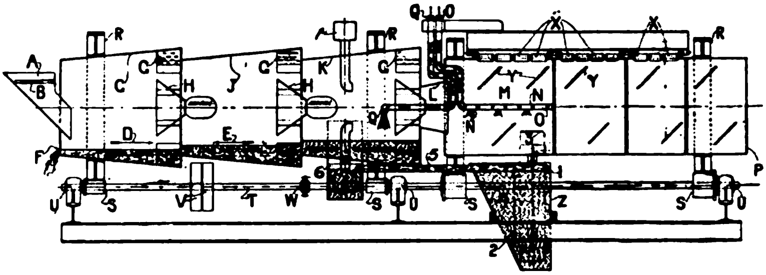
By the patented arrangement of divided barrels containing water of gradually increasing depths, the water cannot co-mingle, except in the direction of its flow; and the cleaner the gravel becomes the cleaner is the water it encounters on its travel to the screen end of the washer. This gives an excellent washing method, and the number of compartments may vary as called for by the work to be accomplished.

The gravel on dropping into the third compartment (K) is in practically clean water, and here it receives its final washing before it is discharged through the cone (L) into the revolving barrel screen (M), where the sand is washed off by clean



"Southall" Gravel Washer.

spraying water issuing at a pressure from the patent spraying jets (N) fixed in the pipe (O); this water carries the fine material into the sand and water separator tank (1). The material which is too large to go through screen (M) travels on through other screens perforated with holes of sizes to give the desired grading, the large rejects falling out at (P). The clean water for the main washing is introduced into compartment (K) through pipe (Q).



When a washer is fitted with the patent separator (Z) it is recommended that the water for both washing and spraying be all introduced through the spraying pipe (O), in which case, before putting any gravel into the washer, the clean water is turned on into the spraying pipe (O) and the washer revolved until the water overflows at (F), after which the gravel can feed into the hopper (A), thus dispensing into the water supply pipe (Q).

The barrel and screens are carried on wide-turned track rings (R) running on turned rollers (S), the friction between their surfaces serving to revolve the barrel and screens. The rollers (S) are mounted on two side shafts (T) running in roller bearings (U), and on one of these side shafts is mounted a pair of fast and loose pulleys (V) for the belt drive, the two shafts being connected by chain and sprocket wheel gearing (W).

Along the top of the screens a series of rollers (X) are provided, hung on swinging links to hammer out of the holes in the screens any pebbles that have wedged themselves into their perforations, an arrangement that saves considerable trouble and secures the full efficiency of the screens. The blades (Y) in the screen are to pass the gravel through them.

The patent separator (Z) shown under the fine screen (M) separates the sand and water passing through it, and both fall into the tank (1) which is fitted with a bucket elevator set at an angle of, say, 45 degrees. This elevator works in part of tank (1), divided off by a division plate (2) in order that the disturbance to the water caused by the moving elevator buckets (3) shall not be communicated to the water in part (4) of tank (1), thus allowing the sand to settle better in part (4). This sand finds its way under the bottom of the division plate (2) to the buckets (3) which dredge the sand up and deliver it at the side of the washer.

The overflow water from tank (1) is conveyed by a pipe or trough (5) into a tank (6), from which it is scooped out by six pipe arms (7) which deliver the water into compartment (K) to help do the washing, thus saving such water from running to waste.

It will be noticed that the rollers (S) on which run the turned tracks (R) of the screens are of larger diameter than the rollers (S) the tracks (R) of the barrels, an arrangement which revolves the screens about half as fast again as the barrels and thus renders the screens more efficient.

DATA FOR PRICING REINFORCED CONCRETE.*

MATERIALS DELIVERED 4 MILES FROM CHARING CROSS.

		s.	d.
Best Washed Sand	per yard	16	0
Clean Shingle, ¾ in. mesh	„	14	0
„ „ ⅜ in. mesh	„	15	6
Thames ballast	„	10	6
Broken brick (¾ in.)	„	11	6
Best British Portland Cement (delivered London area)	per ton 58s. to	63	6

"Ferrocrete" Rapid-Hardening Portland Cement delivered London 10s. per ton extra

		s.	d.
"Super-Cement"	per ton 88s. to	93	0
"Lightning" Brand Aluminous Cement	„ 100s. to	105	6
Ciment Fondu	works f.o.r.	95	0

Boarding for Shuttering—

		Sawn. s.	Sawn. d.	Wrot. s.	Wrot. d.
1 in.	per square	23	6	27	6
1¼ in.	„	29	6	33	6
1½ in.	„	35	6	41	0

Sawn Timber for Struts and Supports—

3 in. by 4 in.	from £22 per standard
3 in. by 6 in. and 3 in. by 7 in.	„ £20 „ „

Mild Steel Rods for Reinforcement—

		s.	d.
⅝ in. to 2⅞ in. Rounds	per cwt.	10	6
7/16 in. to ½ in. Rounds	„	10	9
⅜ in. Rounds	„	11	0
¼ in. Rounds	„	12	0

Breeze Slabs per yd. super: 2 in., 1/11; 2½ in., 2/4; 3 in., 2/9; 4 in., 3/6.

MATERIAL AND LABOUR, INCLUDING 10 PER CENT. PROFIT.

(Based on Contracts up to £2,000.)

Portland Cement Concrete well mixed in proportion 1 : 2 : 4—

				s.	d.
Do.	do.	in foundation	per foot cube	1	11
Do.	do.	in columns	„ „	2	1
Do.	do.	in beams	„ „	2	3
Do.	do.	in floor slabs 4 in. thick	per yard super	6	0
Do.	do.	in floor slabs 5 in. thick	„ „	7	6
Do.	do.	in floor slabs 6 in. thick	„ „	9	0
Do.	do.	in floor slabs 7 in. thick	„ „	10	6
Do.	do.	in walls 6 in. thick	„ „	8	8

(Add for hoisting 3s. 6d. per yard cube above ground-floor level. Add for "Ferrocrete" 1s. 10d. per yard cube.)

Steel Reinforcement, including Cutting, Bending and putting into Position and securing with Stout Binding Wire—

		s.	d.
From ¼ in. to ⅜ in.	per cwt.	22	6
„ 7/16 in. to ½ in.	„	21	6
„ ⅝ in. to 2⅞ in.	„	20	6

EXTRA LABOUR TO BENDS in ¼-in. rods, ½d.; ⅜-in. rods, 1d.; ½-in. rods, 1¼d.; ⅝-in. rods, 1½d.; ¾-in. rods, 1¾d.; ⅞-in. rods, 2d.; 1-in. rods, 2¼d.; 1⅛-in. rods, 3d.; 1¼-in. rods, 3½d.; 1⅜-in. rods, 4½d.; 1½-in. rods. 6d. (per bend per cwt.).

EXTRA LABOUR TO HOOK BENDS: ¼ in., 1d.; ⅜ in., 2d.; ½ in., 2½d.; ⅝ in., 3d.; ¾ in., 3½d.; ⅞ in., 4d.; 1 in., 4½d.; 1¼ in., 6d.; 1½ in., 7d. (per bend per cwt.).

Shuttering—

		s.	d.
Shuttering and Supports for Concrete Walls (both sides measured)	per square	59	0
Centering to Soffits of Reinforced Concrete Floors and Strutting, average 10 ft. high	per square	55	0
Do. do. in small quantities	per ft. super	0	10
Shuttering and Supports to Stanchions for easy removal, average 18 in. by 18 in.	per ft. super	0	11½
Do. do. as last, in narrow widths	„ „	1	1½
Do. do. to sides and soffits of beams, average 9 in. by 12 in.	„ „	1	1½
Do. do. as last, in narrow widths	„ „	1	3½
Raking, cutting, and waste to shuttering	per ft. run	0	3
Labour, splay on ditto	„ „	0	2
Small angle fillets fixed to internal angles of shuttering to form chamfer	„ „	0	3

WAGES.—The rates of wages on which the above prices are based are:—Carpenters and joiners, 1/9½ per hour; Carpenters working on old shuttering, 1/10½; Labourers on building works, 1/4½; Men on mixers and hoists, 1/5½; Bar-benders, 1/5½.

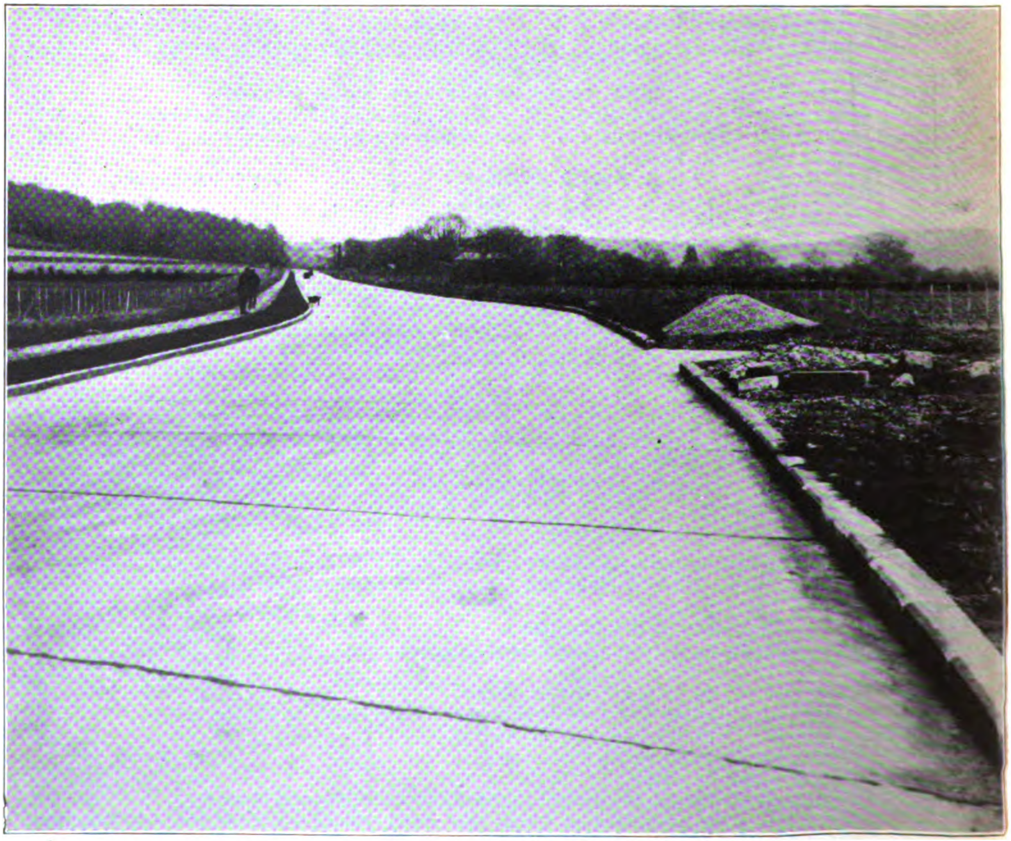
(* This Data is specially compiled for *Concrete and Constructional Engineering*, and is strictly copyright.)

Designing Concrete for Maximum Strength.

As is mentioned in the Editorial pages of this number, recent advances in the scientific knowledge of concrete making have proved that it is quite a simple matter to produce a concrete of predetermined strength. It has also been proved that a 1 : 10 mix can be made as strong as a 1 : 6 mix providing the materials are properly graded and the water content accurately gauged.

The investigations that proved these facts have long passed the laboratory stage. The methods to which they pointed as correct have been used in constructional and pre-cast work, with the result that the strength of every part of the work is exactly up to the specification—nothing more and nothing less. Thus the maker is assured of concrete about the strength of which there can be no doubt, and benefits by a considerable saving in cement.

These methods and processes have now been published in book form, in which the author explains in simple language how this scientific control of the strength of concrete is brought about in practice. The procedure to be followed to secure the best grading according to the aggregate used, and the correct amount of water to be used to secure the most economical use of cement, are fully detailed. Copious illustrations are given, together with several useful charts for use in proportioning for definite strength. Copies may be obtained from Concrete Publications, Ltd., 20 Dartmouth Street, Westminster, S.W.1, price 1*s.* (by post 1*s.* 2*d.*).



The All-Concrete Canterbury By-Pass, just completed for the Kent County Council (Mr. H. T. Chapman, County Surveyor). The road is 8 in. thick, reinforced with B.R.C. fabric.

Prospective New Concrete Work.

ANTRIM.—*Concrete Roads.*—The C.C. has applied for sanction to borrow £45,000 for the reconstruction in reinforced concrete of certain Class 1 roads.

BATH.—*Houses.*—The Council has applied for permission to borrow £86,192 for the erection of 280 houses on the Southdown site.

BEBINGTON. — *Houses.* — The U.D.C. proposes to erect 218 houses on the Stanton estate.

BETHESDA. — *Concrete Houses.* — The U.D.C. is considering the erection of concrete houses.

BEXLEY.—*Concrete Bungalows.*—The U.D.C. proposes to erect 50 concrete bungalows on the "Nash" system.

BIRKENHEAD.—*Houses.*—The Corporation proposes to spend £331,288 on the construction of 621 houses.

BOLTON.—*Road.*—A scheme is being considered for the construction of a road from Bolton to Bury. The cost is estimated at £500,000.

BROMLEY. — *Concrete Houses.* — The R.D.C. proposes to construct 40 concrete houses on the "Nash" system at Chelsfield and St. Mary Cray.

BURNLEY.—*Bridge.*—The T.C. proposes to construct a footbridge over the railway to connect up the Accrington Road and Whittlefield districts.

CANVEY ISLAND.—*Concrete Road.*—A scheme has been submitted to the U.D.C. for the construction of a reinforced concrete road four miles in length, and a bridge to the mainland. The cost is estimated at £155,000.

CHEDDAR. — *Reservoir.* — The Bristol Waterworks Co. is applying for Parliamentary powers to construct a reservoir at Cheddar.

DUNDEE.—*Houses.*—The Corporation Housing Committee recommends the construction of 500 houses.

FEATHERSTONE.—*Houses.*—The U.D.C. proposes to build 82 houses in Ackwood Road, at an estimated cost of £37,200.

GLASTONBURY.—*Houses.*—The T.C. has been recommended to build 48 houses.

GRAVESEND. — *Houses.* — The Council has been recommended to erect 100 houses on the estate in Kitchener Avenue.

GREENOCK.—*Houses.*—The T.C. proposes to build 162 houses at Bow Farm.

HASTINGS.—*Groynes.*—The T.C. has applied for sanction to borrow £14,200 for the construction of groynes.

HEMSWORTH (YORKS). — *Reservoir.* — The U.D.C. proposes to construct a reservoir.

HEYSHAM.—*Sea Defence Works.*—The U.D.C. is considering a scheme for sea defence work in connection with the Sandylands Promenade.

JOHNSTONE.—*Houses.*—The T.C. is considering a scheme for the erection of 192 houses.

KINGUSSIE. — *Road.* — The Aberdeen T.C. and other interested authorities are considering a proposal to construct a road from Linn of Dee, through Glenfeshire, to Kingussie.

KIRKINTILLOCH. — *Houses.* — Application has been made for sanction to borrow £32,400 for the erection of 72 houses at East High Street.

LARNE.—*Road.*—The U.D.C. proposes to construct a 36-ft. wide road from Old Glenarm Road to Roddens Road.

LOCHABAR.—*Bridge.*—Plans are being prepared for the construction of a bridge across the river Lochy. The cost is estimated at £30,000.

SITUATION WANTED.

TO CONCRETE SPECIALISTS.—Engineer, 26, B.Sc., with 2 years work shops, 6 years D.O., including 3 years on structural steelwork and industrial plant, and last 4 years on ferro-concrete design, construction organisation and field control direction, etc., desires appointment. Has worked up to now on own initiative, but desires opening in specialist office. Has ingenuity, confidence, and is willing to learn. Please apply Box 1267, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 20 Dartmouth Street, S.W.1.

WATERPROOFING.

ENGINEERS in concrete and other construction interested in the introduction of sound Waterproofing Compounds who are desirous of taking up the position of Stockholders, embracing areas covering Counties of Great Britain and Ireland, for an English Company situated in London, are invited to forward applications with a view to early negotiations and arrangement for appointment. Apply Box No. 1266, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 20 Dartmouth Street, Westminster, S.W.1.

PATENT.

THE Proprietor of the Patent No. 222151 for Process of Manufacturing Cementitious Materials is desirous of entering into arrangements by way of licence and otherwise on reasonable terms for the purpose of exploiting the same and ensuring its full development and practical working in this country. All communications should be addressed in the first instance to Haseltine, Lake & Co., Chartered Patent Agents, 28 Southampton Buildings, Chancery Lane, London, W.C.2.

Macclesfield. — *Houses.* — The T.C. has decided to erect 100 houses.

Norwich.—*Houses.*—The T.C. is considering a proposal to build 250 houses on the Earlham estate.

Nottingham. — *Bridge.* — A scheme has been submitted for the construction of a bridge in Perry Road. The cost is estimated at £8,000.

Nuneaton.—*Houses.*—The T.C. proposes to erect 80 houses on the Central Avenue site.

Nunsthorpe.—*Houses.*—The Grimsby T.C. has made application for sanction to borrow £28,760 for the construction of 64 houses.

Oldbury. — *Houses.* — The District Council proposes to build 100 houses on the Londonderry Farm estate at Warley.

Otley.—*Bridge.*—The U.D.C. is considering a scheme for the construction of a bridge over the river Wharfe.

Plymouth.—*Houses.*—Application has been made for sanction to borrow £103,214 for the erection of 208 houses on the Higher Mount Gold site.

Porthcawl.—*Sea Wall.*—The U.D.C. has decided to construct a sea wall, promenade, swimming bath, etc.

Salcombe.—*Reservoir.*—The U.D.C. has applied for sanction to borrow £4,400 for the construction of a service reservoir.

South Molton.—*Bridge.*—The R.D.C. has decided to construct a bridge over the river Dart at Bradford Mill, Witheridge.

Stafford.—*Houses.*—The T.C. has made application for sanction to borrow £29,500 for the erection of 58 houses on the Tithe Barn estate.

Stalybridge.—*Houses.*—The T.C. has applied for sanction to borrow £28,000 for housing purposes.

Stamford.—*Road.*—A by-pass road is to be constructed around the town. The cost is estimated at £33,300.

Stareton.—*Bridge.*—The Warwick C.C. proposes to construct a bridge to replace the old Stare Bridge.

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Stirling.—*Bridge.*—The Stirling C.C. has been recommended to consider a scheme for the construction of a footbridge across the River Forth at the Abbey Ferry.

Stretford.—*Houses.* — The U.D.C. has applied for permission to borrow £37,753 for the construction of 82 houses in Hancock Street.

Thorterdykes.—*Houses.*—The Hawick T.C. has applied for sanction to borrow £19,000 for a housing scheme.

Ulverston.—*Sea Defence Work.*—The R.D.C. proposes to spend £6,500 on the construction of a reinforced concrete sea wall.

Uxbridge.—*Houses.*—The U.D.C. has instructed the Surveyor to prepare plans for the erection of 52 houses on the Rockingham Meadows estate.

Whitchurch, Salop.—*Houses.*—The U.D.C. has decided to erect 60 houses.

Wick.—*Concrete Road.*—The Littlehampton U.D.C. proposes to spend £3,840 in reconstructing Worthing Road in reinforced concrete.

Wisbech.—*Road.*—The Isle of Ely C.C. is considering a proposal to construct a by-pass road. The cost is estimated at £24,129.

Tenders Accepted.

Atcham (Salop).—*Concrete Bridge.*—The Salop C.C. has accepted the tender of Messrs. Grays Ferro-Concrete Co., Ltd., at £58,966, for the construction of a reinforced concrete bridge over the Severn.

Axbridge. — *Concrete Houses.* — The R.D.C. has accepted the tender of Messrs. Burston & Hawkins, Clevedon, at £3,728, for the erection of 8 concrete cottages.

Borrowdale (Cumbs.). — *Concrete Bridge.*—The Cumberland C.C. has accepted the tender of the Bridge & Engineering Co., Banbury, at £2,000, for the construction of a reinforced concrete bridge across the Derwent.

Glasgow.—*Concrete Houses.*—The T.C. has accepted the tender of Messrs. Henry Boot & Sons, Ltd., for the erection of 546 concrete houses.

Hastings.—*Concrete Piling.*—The T.C. has accepted the tender of Messrs. J. & W. Stewart, at £5,991, for the construction of reinforced concrete piling.

Hull.—The Corporation has accepted the tender of Mr. R. G. Tarran, Lambert Street, Hull, at £1,527, for the construction of a concrete basement.

Lytham St. Annes.—*Concrete Sewer.*—The T.C. has accepted the tender of Messrs. J. Byrom, Ltd., Bury, for the construction of 700 yds. of concrete sewer.

Sheffield.—*Housing.*—The T.C. has accepted the tender of Messrs. Hodkin & Jones, at £596, for concrete work required to strengthen eight houses.

Stoke-on-Trent.—*Concrete Reservoir.*—The Staffordshire Potteries Water Board has accepted the tender of Messrs. Henry Hayes (Manchester), Ltd., for the construction of a reinforced concrete reservoir.

Whitby.—*Concrete Bridge.*—The T.C. has accepted the tender of Messrs. John Gill, Ltd., at £400, for the construction of a reinforced concrete bridge at the approach of the East Pier.

Recent Patent Applications.

243,308.—E. I. Lindman : Porous concrete.
247,952.—W. Klinke : Ferro-concrete floors.
249,840.—G. Lucknam : Filling cracks by cement under pressure.
250,599.—J. W. Fuller : Cement.
251,621.—P. Allaire : Reinforced concrete.
251,967.—E. Van Bavegem : Concrete construction.
252,210.—O. Lindemann : Mortars and cements.
256,987.—F. L. Smidth and Co., Aktieselskabet : Cement.
258,293.—T. Fusoni : Concrete mixer.
259,203.—U. B. Voisin : Cements.
260,313.—J. Melandri and Spun Concrete Construction Co. : Building blocks.
260,447.—C. Pontoppidan and S. Buntzen : Production of cement.
260,495.—P. Allaire : Reinforced concrete elements.
260,792.—L. Pantani and J. France : Concrete brick.
261,072.—J. W. Waller and C. Walker : Concrete blocks.
261,814.—T. Rigby : Cement.
261,846.—J. H. Bennetts, D. Palmer-Jones, D. H. Jones and Scaffolding (Great Britain), Ltd. : Casting or moulding cementitious materials.
261,910.—Ransomes & Rapier, Ltd., and P. D. Ionides : Concrete mixing apparatus.
261,952.—J. Pickerill : Concrete blocks.
262,252.—Ransomes and Rapier, Ltd., and P. D. Ionides : Charging concrete.
262,525.—Vickers, Ltd., and L. D. Parker : Rotary kilns for burning cement.
262,982.—G. Jaeger : Concrete mixing machines.
263,257.—J. F. H. Crisp : Concrete walls and buildings.
263,571.—J. A. Rice : Cements.
263,997.—J. Saxild and C. F. A. Ingerslev : Quay walls and piers.
264,254.—I. Gardner : Concrete structures.
264,547.—The Duke of Atholl : Building construction.
264,580.—J. Muller : Concrete blocks.
264,711.—P. Cadre : Cement.
264,715.—G. Maxwell : Concrete-block construction.
264,760.—J. Fahey : Moulding concrete.
264,782.—The Duke of Atholl : Building construction.

New Companies Registered.

ANSTON STONE AND CONCRETE CO., LTD. (219329). Registered, February 1. Nominal capital, £3,000.

CONCRETE FORM ERECTING AND CONSTRUCTION CO., LTD. (217830). Registered November 29. Contractors for erecting shuttering for concrete construction, builders, etc. Nominal capital, £200. Directors: A. A. A. Byrd, Chase Side, Crescent Road, Chingford; H. Tuckey, 11 Allington Street, Brixton Hill, S.W.; A. W. Surridge.

CORNWALL CONCRETE CONSTRUCTION CO., LTD. (217573). Registered November 17. Stone merchants and makers of concrete blocks, Commercial Square, Camborne. Nominal capital, £5,000. Directors: W. F. S. Hodge, The Public Rooms, Truro; E C. Thomas, Commercial Square, Camborne; J. F. F. Trelawney, 639 Salisbury House, London Wall, E.C.

DE ROS, BARTON & MESSMER, LTD. (218144). Registered December 13. To treat, manufacture and deal in cement, stone, concrete, etc. Nominal capital, £1,000. Directors: H. W. Newby (chairman); Otto Messmer; D. de Rose, F. Barton. Subscribers: A. W. Slade, 73 Nichols Square, Hackney Road, E.; C. G. Cave, 21 Cholmondeley Avenue, Harlesden, N.W.10.

NORTHERN CONCRETE BLOCK & SLAB CO., LTD. (218814). Ivy House, Mannby, near Thirsk, Yorks. (Registered January 8.) Nominal capital £1,000. Directors: F. H. Stephenson, 45 Eastwell Terrace, Ripon Road, Harrogate; G. A. Clarke, Ivy Bank, Haworth.

OXFORD AND SHIPTON CEMENT LTD. (219244). Registered January 27. To acquire the undertaking and business of the Oxford Portland Cement Co., Ltd., Kirtlington, Oxon. Directors: A. H. Dillon, J.P., Barton Lodge, Steeple Aston, Oxford; Sir John Brunner, Bt., 43 Harrington Gardens, S.W.7; Lord Ivor Spencer Churchill, 9 Chelsea Embankment, S.W.; G. V. Maxted, Rhondda, Barnet Lane, Elstree; H. L. Mond, 45 Green Street, W.1; H. S. Wilson, 13 Southwell Gardens, S.W.

PATCHETTS CONCRETE WORKS LTD. (219054). Registered January 19. Nominal capital: £2,000. Provisional directors: W. J. Patchetts, 4 Crofton Avenue, Hillsborough, Sheffield; W. Waterhouse, 122 Brincliffe Edge Road, Sheffield.

Trade Notices.

Road Reinforcement.—Electrically welded square mesh B.R.C. fabric, which is supplied in rolls, is being used in the foundation of the Borough High Street, also at the junction of Waterloo Road and Westminster Bridge Road, London. This work is being done under the direction of Mr. A. Harrison, the Surveyor for the Southwark Borough Council.

Edgar Allen & Co., Ltd.—We have received from Messrs. Edgar Allen & Co., Ltd., of Sheffield, a new book issued by them entitled " A Century of Permanent Way," by Mr. F. Bland, M.I.Mech.E., F.S.A. The first section contains Mr. Bland's paper under this title delivered last year at the Annual Convention of the Permanent Way Institution, and also his interesting paper on " Atmospheric Railways " recently published in the "Edgar Allen News." Both these papers give historical details in connection with the growth of permanent way. The second section of the book is entitled " Modern Manganese Steel Trackwork," and replaces the old Edgar Allen Catalogue F (" Railway Switches and Crossings "). This section describes the development in the use of Imperial manganese steel for railway track-work, indicates the advantages of patent-rolled manganese steel rails, and contains a number of interesting technical details and tables of use to all permanent way engineers, besides a large number of illustrations of track-work produced by the firm. It is interesting to note that thirty-seven of the world's railways have placed orders with this firm for Imperial manganese steel track-work.—We have also received a copy of the second edition of " Imperial Stainless Steel and Iron," which gives the main facts about rust-resisting steels, including notes on mechanical properties, heat-treatments, and uses.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XXII. No. 4. LONDON, APRIL, 1927.

EDITORIAL NOTE.

Bridge Failure in Germany.

As the daily press reported a few months ago, the new bridge over the river Oder at Gartz, which is about fifteen miles above Stettin, was destroyed on September 19 of last year. Although the cause of this disaster, which occurred only a week before the date arranged for the opening ceremony, has not been finally established, still it is agreed that the accident arose from the failure of one of the piers which dragged the adjacent spans into the river.

The structure was of three spans, the middle one of about 190 ft. and the two equal side spans of about 123 ft. each ; the superstructure was constructed as two-hinged arched ribs with tie-rods. High-strength cement and high-tensile steel were used for the members, which were subjected to pure tension. The whole structure was poured by chuting in the remarkably short time of four months.

As a result of the accident the superstructure of the south span was pushed about one yard over its support at the bank end and remained with its end leaning against this support. The other end of this span, which originally was supported by the pier which failed, was precipitated into the bed of the river about 40 ft. below. The arc of the middle span was shattered by the impact of the fall at the place where the first wind-bracing member was connected to it.

In view of the very high stresses which must have been caused by the fall of the span it is interesting to note that the south span of the bridge does not show the smallest damage or the slightest crack in either the arch or the floor. The tie member alone exhibits a slight hair crack. This remarkable behaviour of the superstructure, over its greater part, is clear evidence of the suitability of the material to resist such extraordinary impact stresses and of the care which had been exercised during the construction of the work.

In the middle span the arch was broken in two places (see illustration on p. 236) where the main steel was bent into an **S**-curve of extraordinarily sharp radii without cracking any of the bars. The stirrups on the upper side of the arched beam yielded to the high stresses and cracked, but on the lower side no cracks were visible. Cracks in the concrete are visible in portions of the curved beam which lie above the water.

We have not referred to this accident before in view of the lack of adequate technical data, and even at this stage no authoritative statements as to the cause have been made public. The information here given is abstracted from the German technical press, but until the official report of the examination of the site and structure is available it will not be possible to be certain of the cause of the disaster. So far it is only certain that the structure has exhibited an extraordinary resistance to incalculable stresses caused by the accident.

Scientific Proportioning.

READERS of this journal who have studied the articles we have published from time to time on the cement-water-ratio method of designing concrete mixtures will be interested to know that the subject has now been taken up in the Department of Civil Engineering at the University of Edgbaston under the direction of Professor Cyril Batho, D.Sc., A.M.Inst.C.E. The fourth-year students at Birmingham are now carrying out work in this direction as part of their Laboratory course, and we understand that other engineering schools are considering the question of including the design of concrete mixes for specific strength as part of the regular courses.

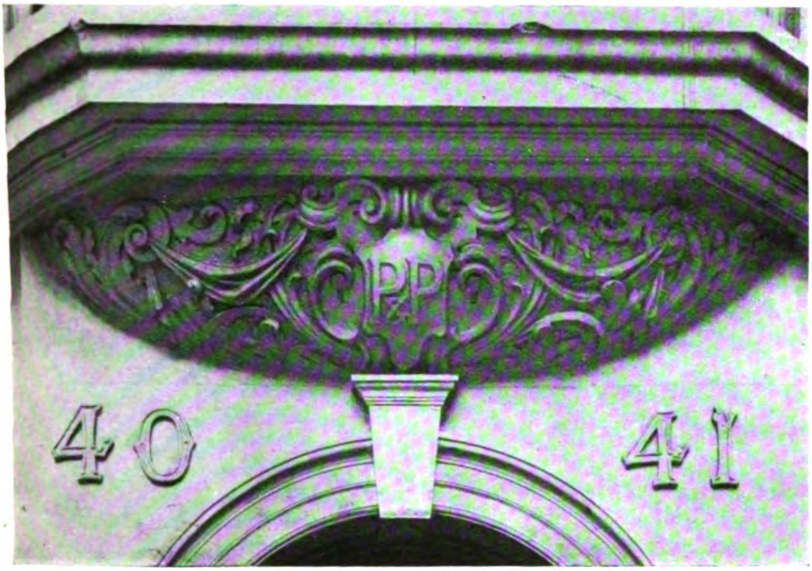
In this number we give an abstract from a report of a committee on the American Concrete Institute specially set up to consider the matter from the practical and economical points of view, from which it will be seen that leading engineers and contractors favour this method of designing concrete mixes on account of the control over strength which it gives to the engineer and the saving in cement effected by the contractor.

An Extraordinary Test.

IN this number we give some particulars of the raising of a reinforced concrete coal bunker that, owing to subsidence, had sunk a distance of 7 ft. at one end only. After the subsidence no trace of a crack could be found in the whole of the structure, which is 143 ft. long by 27 ft. wide by 21 ft. high, and it was successfully raised into its original position without damaging it in any way. This incident is a striking testimony to the strength of a well-built concrete structure, and to the cohesion of the members under exceptionally heavy stresses that could not have been anticipated in the design. It is doubtful whether any other structural material would have successfully withstood such a strain, or have been replaced without rebuilding.

Cast Stone.

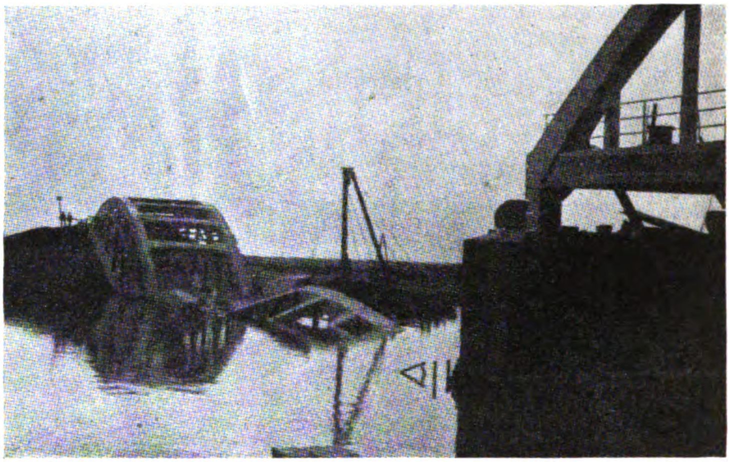
IN this number we illustrate a few buildings recently completed with cast stone elevations, which give some indication of the increasing popularity of this material for the elevations of important buildings in London and elsewhere. The reconstruction of some of the central districts combined with the increased costs have caused architects to look beyond the materials which they have become accustomed to specify almost automatically, and cast stone is one of the " discoveries " that have resulted from the search for something that is in all respects the equal of usual materials but cheaper. The modern cast stone, which is simply natural stone crushed and reconstructed with Portland cement so that it may be shaped



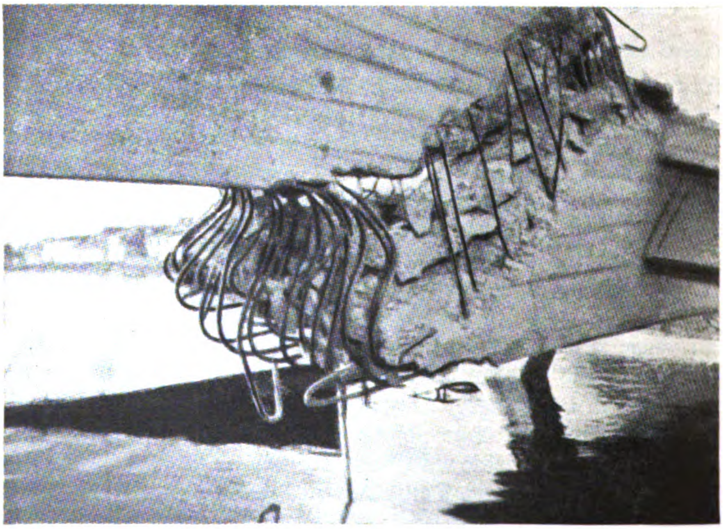
Cast Stone Thirty-Five Years Old.

[This ornamental work, which is on Messrs. Pryke and Palmer's premises in Upper Thames Street, London, was made by Stuart's Granolithic Co., Ltd., thirty-five years ago. Its present excellent condition may be seen from the photograph.]

by the less expensive method of moulding instead of cutting, is gaining in favour with leading architects with a reputation for conservativeness, as may be seen by its extensive use on important public and private buildings. Doubts have sometimes been expressed as to the wearing properties of cast stone, and as to how it will withstand the ravages of London's smoke-laden atmosphere. The material is, of course, of too recent date for comparisons to be made with natural stones erected centuries ago, but some of the earliest cast stone made in this country is still in excellent condition. We illustrate on this page a piece of decorative cast stone that has been in position for thirty-five years in Upper Thames Street; there is a specimen in Limehouse forty years old, which must be one of the very first pieces made and shows no deterioration whatever after its long exposure to the sulphurous atmosphere in which it stands. It is interesting to note that in both these cases Portland stone erected at the same time side by side with the cast stone shows considerable disintegration. Another example of cast stone side by side with natural stone is to be seen by any passer-by on the Audit House on Victoria Embankment; both were erected thirty years ago, and the two have weathered and blended together so well that it is quite impossible to distinguish the one from the other from their appearance—the cast stone work is the coat of arms and urns over the entrance.



General View after Collapse.



Break in Middle Span

Bridge Collapse in Germany. (*See page* 233.)

A Contribution to the Calculation of Circular Tanks in Reinforced Concrete.

By **H. CARPENTER.**

If the sides of a circular tank are monolithic with its base, not only do tensional stresses occur in the wall, but also bending stresses produced by the restraining effect of the base slab.

Referring to *Fig.* 1, the load produced by the water pressure is represented by a triangle varying from zero at water level to a maximum at the base. The load at any depth x is given by the equation $px = wx$, w being the weight of water per unit volume.

Let us now from a statical point of view imagine that the tank wall is divided into two series of structural elements normal to each other, a number of horizontal rings, and a series of vertical beams. The latter act as cantilevers with their ends fixed in the base slab and having their free ends at the top of the wall. The two structural components are clearly expressed by the arrangement of the reinforcement in the shape of horizontal rings and vertical rods.

It is obvious that the amount of the triangular load acting in the lower parts of the wall will be carried by the cantilevers. The upper portions are taken by the rings. A line separating from each other the portions of the load carried by the two elements is shown in *Fig.* 1, where the cantilever load has received a vertical shading.

In examining the " load distribution line " we note two characteristic features as follows: At the bottom of the wall the total pressure is taken by the cantilevers. Due to the assumption of perfect fixity of the staves into the base slab, the deflection will be zero. Therefore the rings will receive no load at all, and we have $p_c = wh$ at lowest section.

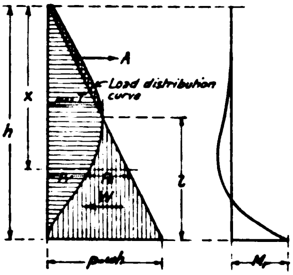


Fig. 1.

In the top parts of the wall pc is of opposite sign, i.e. the cantilevers receive in their upper part a negative load. If no such load of opposite sign were acting near the top of the wall the cantilevers would there receive their greatest deflections, but this obviously cannot be the case owing to the restraint afforded by the rings.

It will be seen from *Fig.* 1 that the load carried by the cantilevers is composed of the forces W and $-A$ acting with opposite sign. They produce a bending moment as shown in the adjoining diagram. In the middle portions of the wall the moment is reversed due to the effect of the small force A.

The exact determination of the load distribution line for a given case depends on the exact knowledge of the deflections at every point of the wall. But this is a tedious task, too lengthy for practical purposes. For this reason the writer proposes to utilise an article by Dr. Lewes, published in "Beton u. Eisen" (March 1915) by the way of giving tables based on the information available in that paper, which is an excellent treatment of the subject from a theoretical point of view.

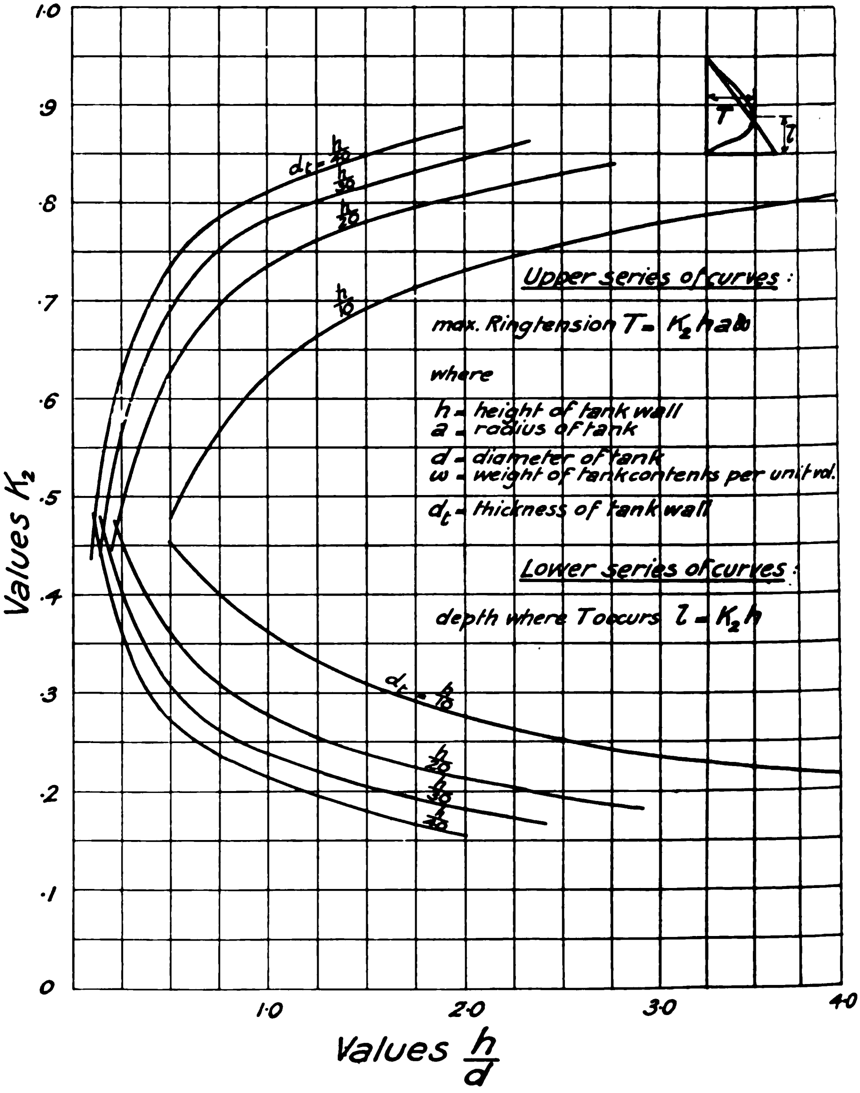


Diagram: Fig. 2.

Fig. 2 has been plotted for the calculation of the maximum value of ring tension and its position as indicated by the diagram at the top of the table. For given values of the ratio $\frac{\text{height of wall}}{\text{diameter of tank}}$ and different thicknesses expressed in terms of the height of the tank the values in question may be readily calculated with the formulæ given on the table.

The mount of the restraint moment at the bottom of the tank may be obtained from Diagram *Fig.* 3.

The following approximate method of obtaining the restraint moment will be of interest, and it will be seen that its results check satisfactorily with those obtained by Table *Fig.* 3.

Let, in *Fig.* 4, curve *abc* represent the load distribution line. The vertical staves are loaded with the forces *W* and — *A*, whereas *R* and + *A* are balanced by the horizontal rings. Now replace curve *ac* by a straight line *ac*. In order to compensate the increase of *W*, assume a force — *a* (represented by the shaded area) to be acting at the centre of gravity of *a*. Forces *A* and *a* combined produce a resultant *x* acting near point *c*. Further to simplify the calculations we assume the point of application of *x* to be exactly at *c*, and also the vertical tangent to the curve near point *c* to pass exactly through *c*.

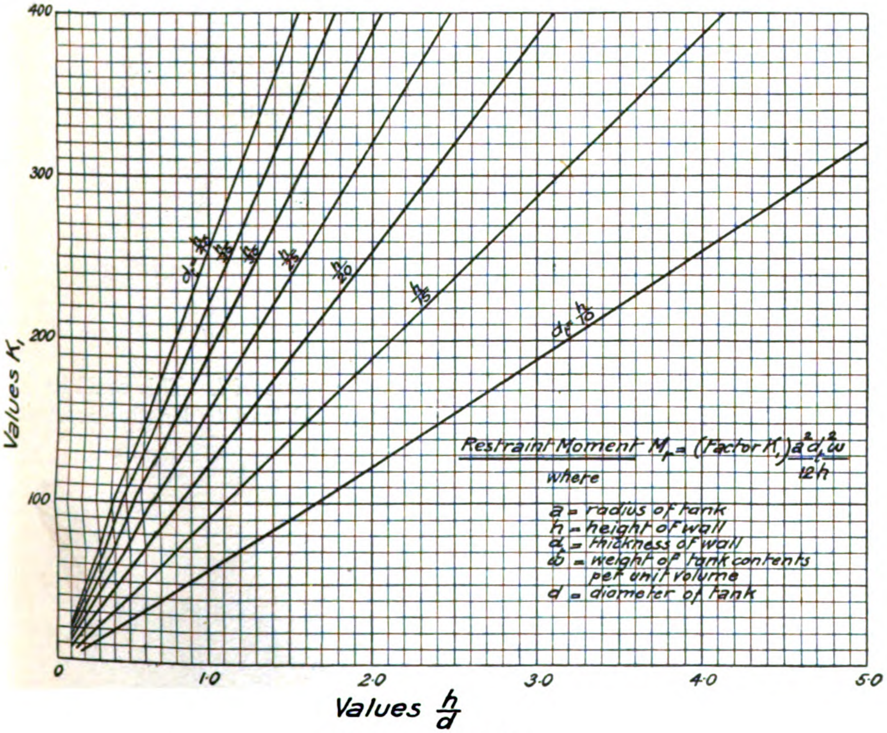


Diagram: Fig. 3.

With these simplifications we may determine the restraint moment in a simple manner. The cantilevers (*Fig.* 5, *a*) are fixed at *a*, loaded with a triangular load represented by the diagram *aa'c'* and a concentrated load *x* acting with opposite sign at c', and have a vertical tangent passing through point c'. The equation to the bending moment at any point is

$$M = \frac{EIdy^2}{d^2x}.$$

Referring to *Fig.* 5 (*b*) we have

$$M_x = EI\frac{dy^2}{d^2x} = \frac{plx}{6} - \frac{px^3}{6l} - M_Y\frac{x}{l}.$$

Now $x = l - x_1$ and $dx = -dx_1$,

therefore
$$EI\frac{dy^2}{d^2x_1} = \frac{px^3}{6l} - \frac{plx}{6} + M_Y\frac{x}{l}$$

Integrating
$$EI\frac{dy}{dx_1} = \frac{px^4}{24l} - \frac{plx^2}{12} + \frac{M_Yx^2}{2l} + C_1$$

At point c' the tangent was assumed to be vertical, therefore

$$\text{for } x = 0 \text{ and } x_1 = l, \ \frac{dy}{dx_1} = 0$$

and therefore $C_1 = 0$

For $x = l$ and $x_1 = 0$, $\frac{dy}{dx_1} = 0$.

Hence
$$0 = \frac{pl^3}{24} - \frac{pl^3}{12} + \frac{M_Yl}{2}$$

$$\therefore M_Y = \frac{pl^2}{12}.$$

There now remains the determination of the value of l. This could be done by further developing the analysis, but this would lead to lengthy expressions not suitable for practical design. For this reason it is proposed to utilise the curves in diagram *Fig.* 2, where the values of l for a tank of given dimensions may be readily obtained. It will be seen from the following examples that this method gives quite reasonable results for tanks with values of $\frac{h}{d} \geqq \cdot 5$

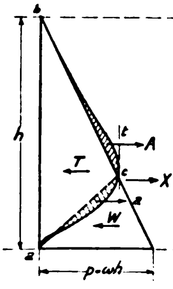


Fig. 4.

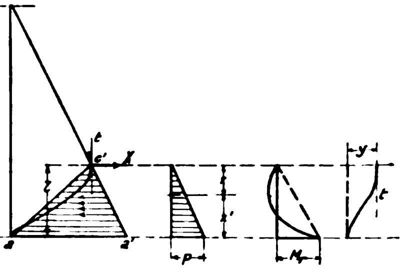


Fig. 5.

In many cases the upper parts of a tank are connected to a roof or dome. But this has little influence on tanks of the usual dimensions owing to the deflections at the top being so small that they may be neglected altogether.

It should be always borne in mind that the assumption of perfect fixity of the wall into the base slab was made, and also that the value of EI was supposed to be constant throughout the height of the tank wall. It is, of course, left to the designer's judgment whether and to what extent the formulæ hold in any particular case. At any rate they give a fair idea of the elastic properties of the tank and should be of assistance to the engineer in preparing the necessary calculations.

Examples :—

(1) Design a tank with dimensions as follows :—

$$h = 20 \text{ ft.},\ d = 20 \text{ ft.},\ d_t = 8 \text{ ins.}$$

$$\frac{h}{d} = \frac{20}{20} = 1{\cdot}0,\ d_t = \frac{h}{30}.$$

From diagram *Fig.* 2 we obtain maximum ring tension

$$T = {\cdot}78 \times 20 \times 10 \times 62{\cdot}5 = 9750 \text{ lbs./ft.}$$

occurring at $l = {\cdot}24 \times 20 = 4{\cdot}8$ ft.

Diagram *Fig.* 3 gives

$$M_\gamma = 192 \times \frac{10^2 \times {\cdot}67^2 \times 62{\cdot}5}{12 \times 20} \times 12 = 26{,}800 \text{ ins.-lbs.}$$

or, by approximate method

$$M_\gamma = (62{\cdot}5 \times 20) \times \frac{4{\cdot}8^2}{12} \times 12 = 27{,}800 \text{ ins.-lbs.}$$

(2) $h = 20$ ft., $d = 50$ ft., $d_t = 12$ ins.

$$\frac{h}{d} = \frac{20}{50} = 0{\cdot}4,\ d_t = \frac{h}{20}$$

$$\text{max. } T = 0{\cdot}58 \times 20 \times 25 \times 62{\cdot}5 = 18{,}125 \text{ lbs./ft.}$$

$$l = 0{\cdot}39 \times 20 = 7{\cdot}8 \text{ ft.}$$

$$M_\gamma = 45 \times \frac{25^2 \times 1{\cdot}0^2 \times 62{\cdot}5}{12 \times 20} \times 12 = 88{,}000 \text{ ins.-lbs.}$$

or, approximately

$$M_\gamma = (62{\cdot}5 \times 20) \times \frac{7{\cdot}8^2}{12} \times 12 = 77{,}000 \text{ ins.-lbs.}$$

This result is less accurate, owing to the shape of the load distribution line for a tank of the given dimensions being not quite in agreement with the assumptions made in the approximate method.

(3) $h = 20$ ft., $d = 50$ ft., $d_t = 15$ ins.

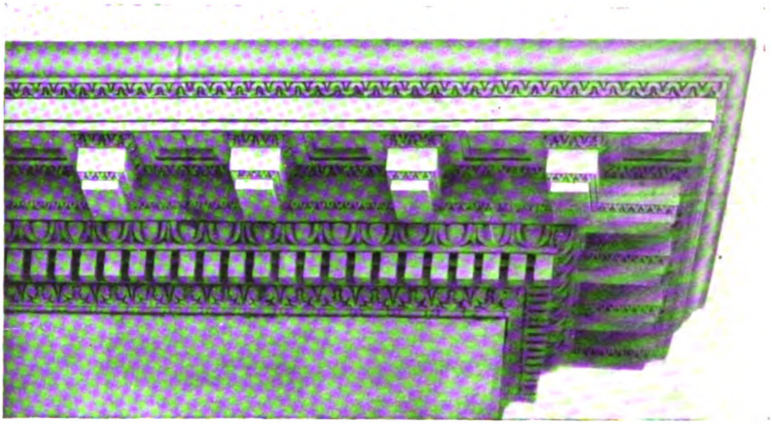
$$\frac{h}{d} = \frac{20}{50} = 0{\cdot}4,\ d_t = \frac{h}{16}$$

$$\text{max. } T = 0{\cdot}54 \times 20 \times 25 \times 62{\cdot}5 = 16{,}875 \text{ lbs./ft.}$$

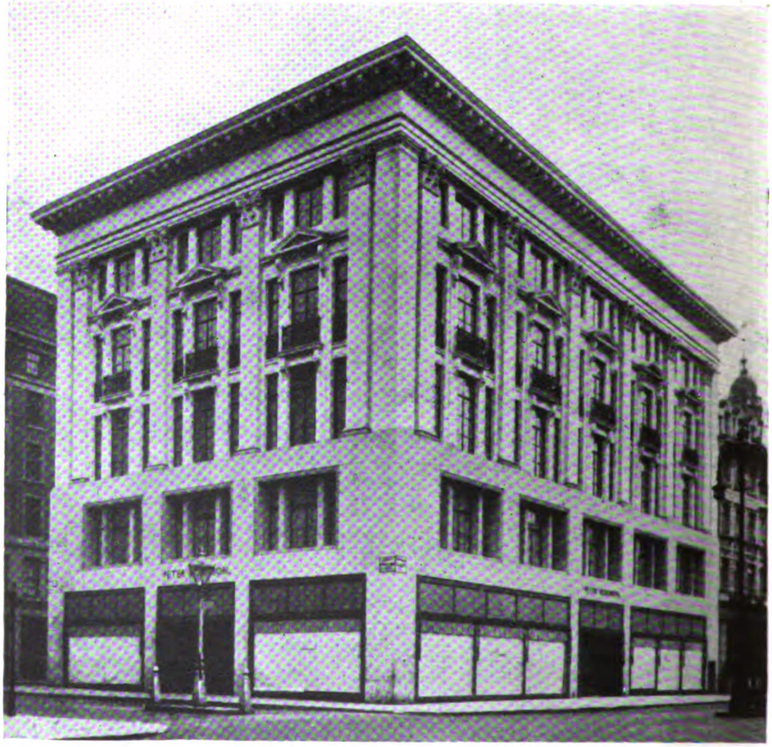
$$l = 0{\cdot}425 \times 20 = 8{\cdot}5 \text{ ft.}$$

$$M_\gamma = 35 \times \frac{25^2 \times 1{\cdot}25^2 \times 62{\cdot}5}{12 \times 20} \times 12 = 107{,}000 \text{ ins.-lbs.}$$

It will be seen from these examples that the bigger the radius and the stiffer the wall the greater will be the restraint moment, a result that is well in agreement with practical considerations.



Detail of Cast Stone Cornice.



Cast Stone by Empire Stone Co., Ltd.

Messrs. Peter Robinson's Premises, Oxford Street and Regent Street, and a detail of the Cast Stone Cornice.

Viaduct and Bridge at Barking.

By GORDON WELCH, B.Sc., A.C.G.I., A.M.Inst.C.E.

THIS bridge, of which a brief description appeared in the February number of *Concrete and Constructional Engineering*, was commenced in May, 1924, and is now completed. On account of its large spans for a bridge of straight girder type, the peculiar engineering difficulties to be overcome, the importance of its position on a new arterial road, and its unusual architectural features, this work is of more than ordinary interest.

Fig. 2 is a photograph of the ⅛-in. scale model of the bridge, and gives a good impression of the work as a whole. The length between abutments is 670 ft., divided between the viaduct, which has a length of 365 ft., and the bridge proper (305 ft.). The overall length of the bridge and viaduct is 720 ft. The width between parapets is 50 ft., providing a 30 ft. roadway and a 10-ft. side walk on each side.

A drawing of the west abutment and span over Jenkins Lane in *Fig.* 5, and of the east abutment and river spans in *Fig.* 4, show clearly the typical massive lines and the pleasing effect obtained by the use of reeded or fluted shuttering throughout the work.

The abutments, founded upon piles 14 in. square driven into good ballast, are of the curtain wall and counterfort type. The height from road level at Jenkins Lane to the deck level of the viaduct, which is also the top of the abutment wall, is approximately 23 ft. and the thickness of the wall (which is horizontally reinforced) varies from 15½ in. at the base to 7 in. at the top. The flanking walls to the abutments are of similar construction, the counterforts throughout being 10 in. thick. At points along the abutment face, where the main beams take bearing, piers 22 in. square, heavily reinforced, have been inserted. These piers, together with the horizontal rustications of the wall, break up the face of the abutment into panels and give an appearance of great strength.

The abutments are surmounted, over each footwalk, by pylons of massive form which provide very significant punctuations to the ends of the work.

The columns to the viaduct are also founded upon piles 14 in. square, driven in groups into good ballast and tied together below ground level by 10-in. by 14-in. reinforced concrete ties. Each group of columns consists of two inner columns 24 in. square reinforced with eight bars of 1 in. diameter and two outer columns 24 in. square at ground level but

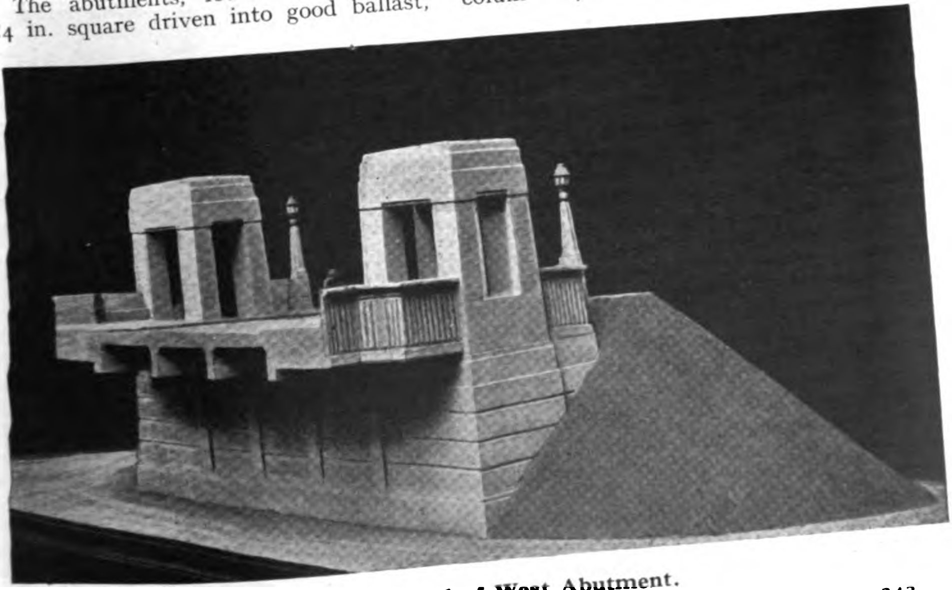


Fig. 1.—Model of West Abutment.

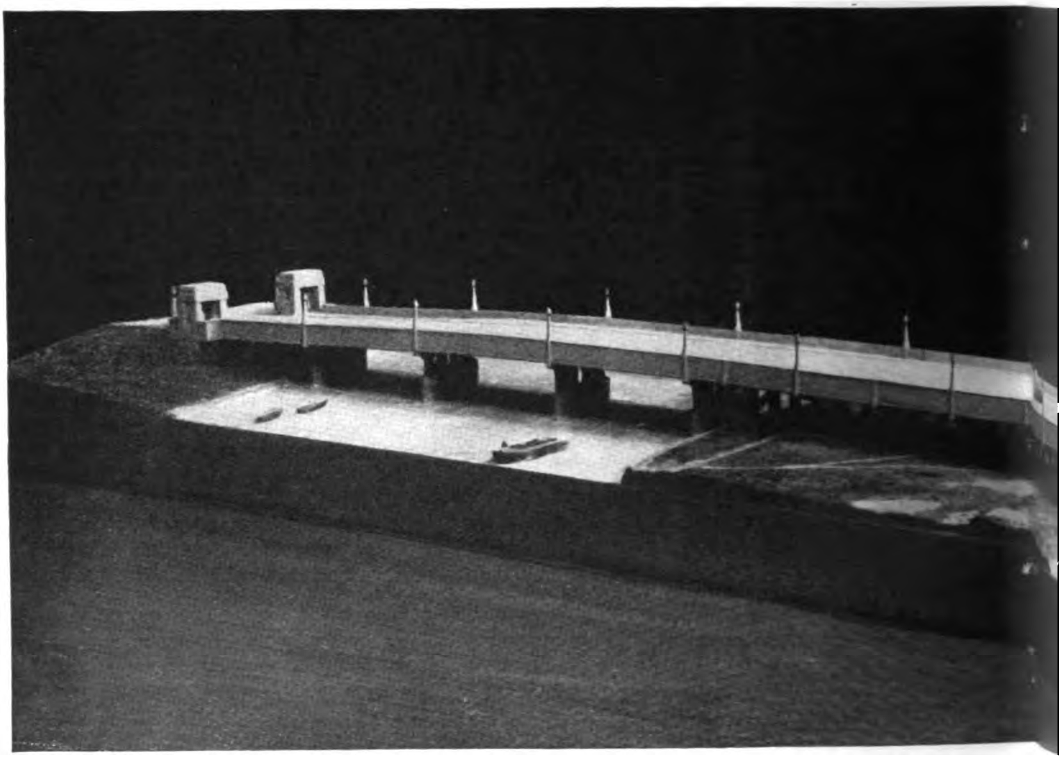
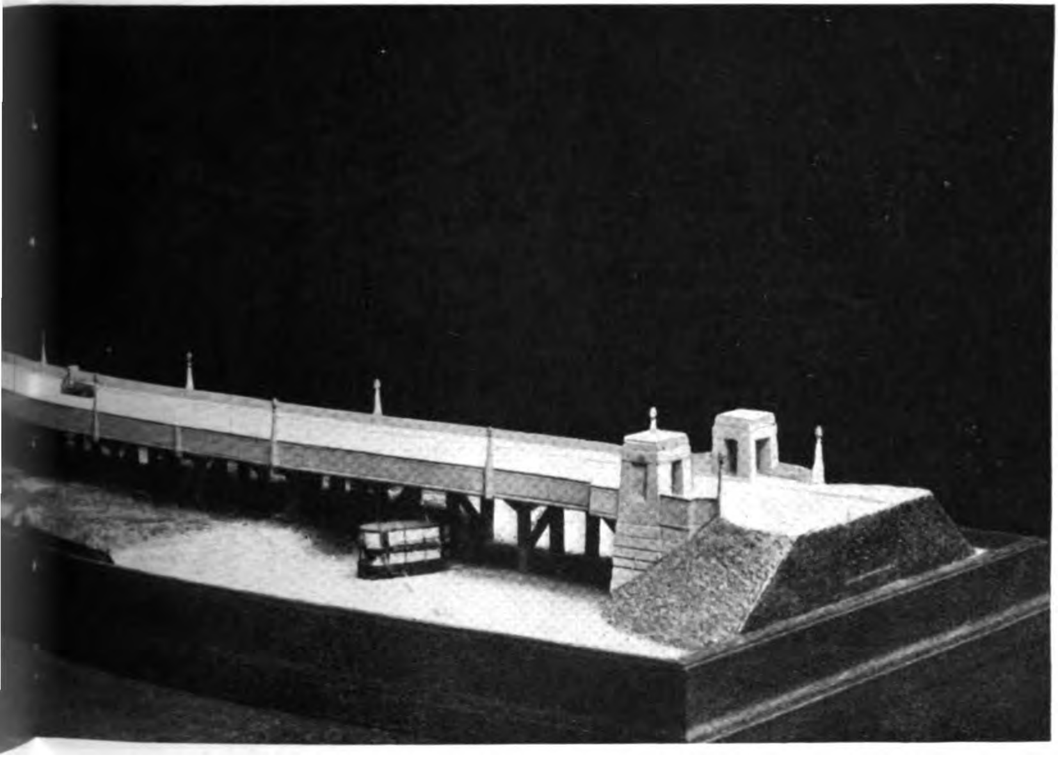


Fig. 2.—NEW VIADUCT AND BRIDGE AT BAR

increasing in section to 24 in. by 42 in. at the springing of the cantilevers which carry the parapets and pipe ducts; the inner face of these columns is kept vertical and the increased dimension obtained by sloping outwards of the outer face. This unusual architectural feature is very pleasing in effect, giving an appearance of additional strength at the point of juncture of two very important structural members. The column heads are tied together just below deck by deep cross-beams 15 in. by 66 in., reinforced with nine bars 1⅛ in. diameter top and bottom. In addition, diagonal braces, 10 in. by 18 in., reinforced with four bars 1⅛ in. diameter, give transverse stiffness to each frame. A typical cross-section of the viaduct is given in *Fig.* 3. A plan and longitudinal section are given on pp. 260–261.

The cantilevers to both viaduct and bridge are again an architectural innovation; an elevation and cross-section are shown in *Fig.* 3. The dimensions here given are those for the viaduct where the reinforcement consists of six bars 1½ in. diameter top and bottom with links ⅜ in. diameter spaced 4 in. apart. Bars were left projecting from these cantilevers in order to bond up with the parapet and parapet piers, which were to be constructed later.

The four river piers to the bridge are of mass concrete construction carried down to a depth of 42 ft. below high water and approximately 28 ft. below the bed of the river and founded upon spread footings upon solid clay. The total height of these piers from foundation level to the top is 50 ft., and the length of each over cutwaters is also 50 ft. The thickness of each pier is 8 ft., the width of the footings being varied according to the loads to be carried. (Photographs of these piers under construction and of the steel sheet pile cofferdams employed were given in *Concrete and Constructional Engineering* for February, 1927.)



R.C. Design by L. G. Mouchel & Partners.

RKING (FROM AN EIGHTH-INCH SCALE MODEL).

The two landward piers, although really in mass concrete, have been reinforced by the addition of vertical and horizontal bars near each face so that in the event of future dredging of the creek these piers will be amply strong to resist bending stresses due to unequal pressures of earth.

The columns to the bridge are 36 in. square, built up from the mass concrete piers in groups as for the viaduct; the outer columns in each group increase to 36 in. by 54 in. at the springing of the cantilevers.

These cantilevers are similar to those of the viaduct, but owing to the heavier loads brought upon them from the 69-ft. and 80-ft. spans of the bridge the dimensions and reinforcements have been correspondingly increased. The parapet and pipe-duct give a load of a little over a ton per foot run, so that these cantilevers have to sustain a point load of nearly 90 tons each and have for reinforcement ten 1¾ in. diameter bars top and bottom with links, ½ in. diameter, spaced 5 in. apart.

The decking to both viaduct and bridge consists of 7-in. concrete slab, reinforced between secondary beams by ½-in. bars laid 4½ in. apart. The secondary beams have a section of 8 in. by 16 in., and are reinforced with four ⅞-in. bars. The main beams spanning between columns are, for the viaduct 14 in. by 42 in., and have deep haunches where they intersect the supports. For the bridge, owing to the large skew of the river, the gradient of deck, and the necessity for keeping the soffit of beams at constant levels, the depth of the main beams varies along their length. In the centre of the 80-ft. span it is 66 in. deep by 20 in. wide, reinforced with twenty 2-in. bars, twelve in the bottom and eight in the top. The two side spans of 69 ft. each are also heavily reinforced, being designed practically as free spans owing to the fact that they were to be cast and stripped before the centre span was built. In this

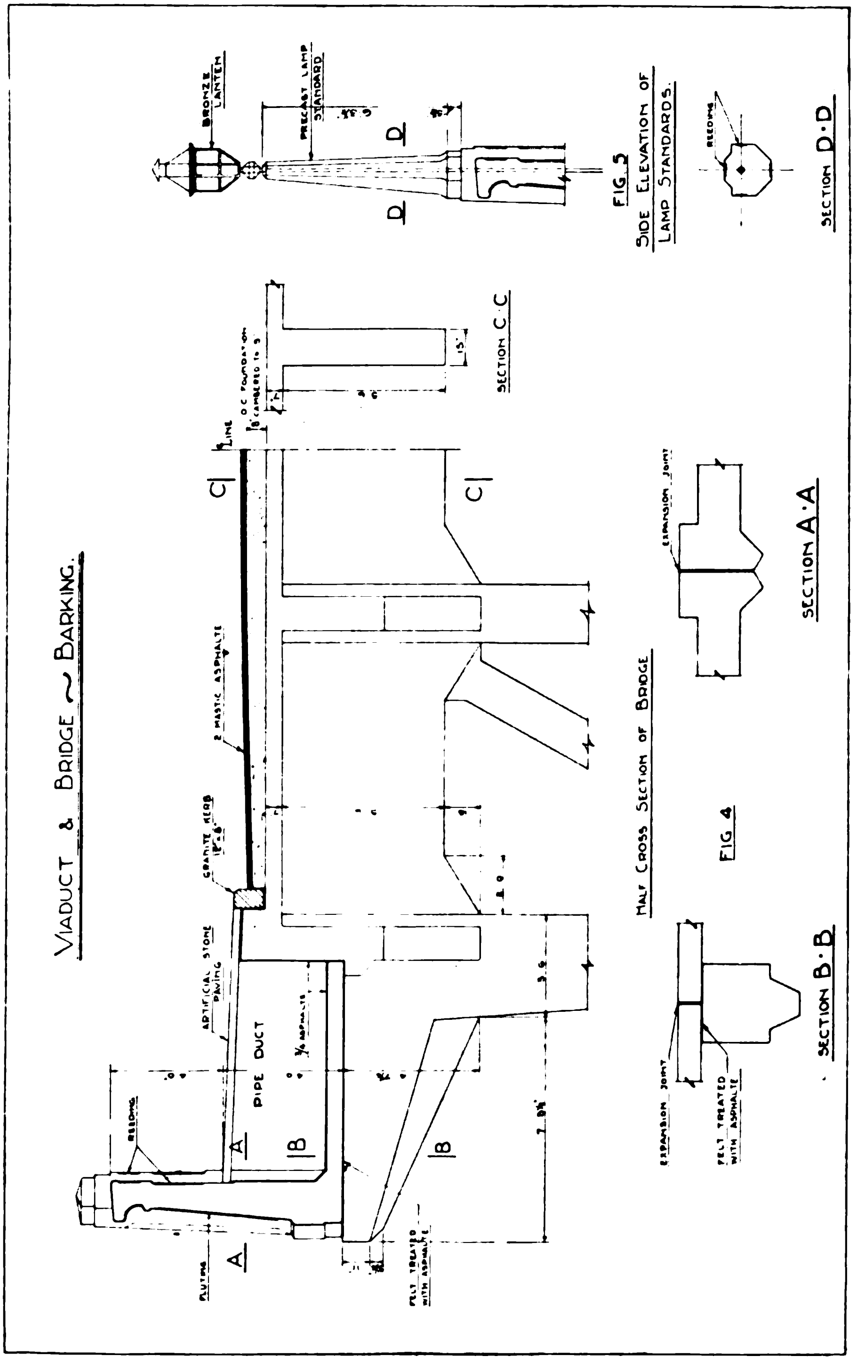


Fig. 3.—Typical Cross-Section of Viaduct.

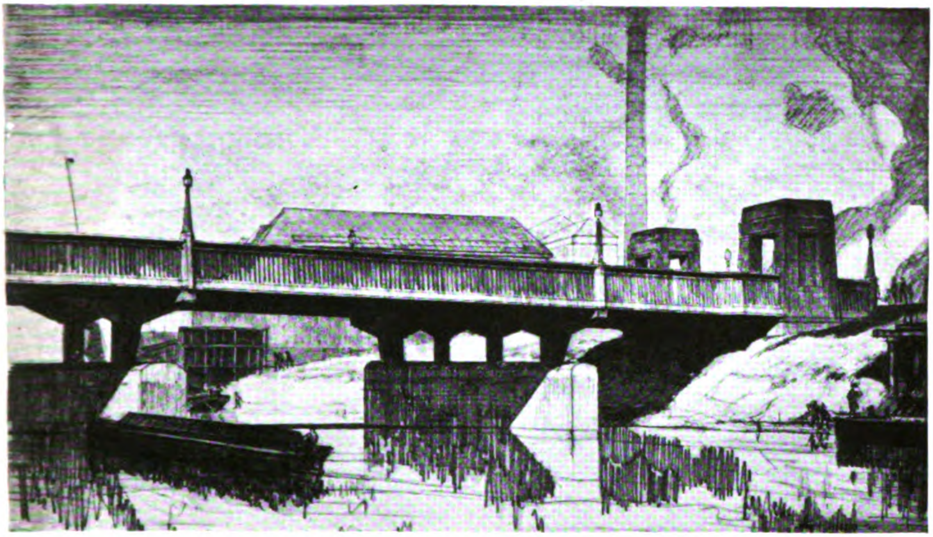


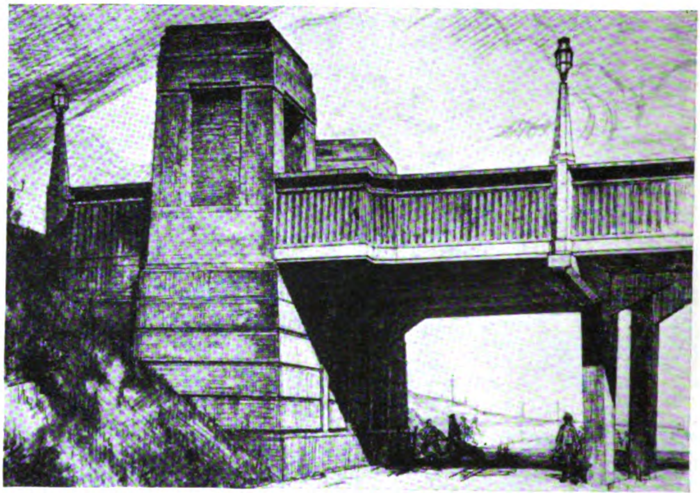
Fig. 4.—East Abutment and River Spans.

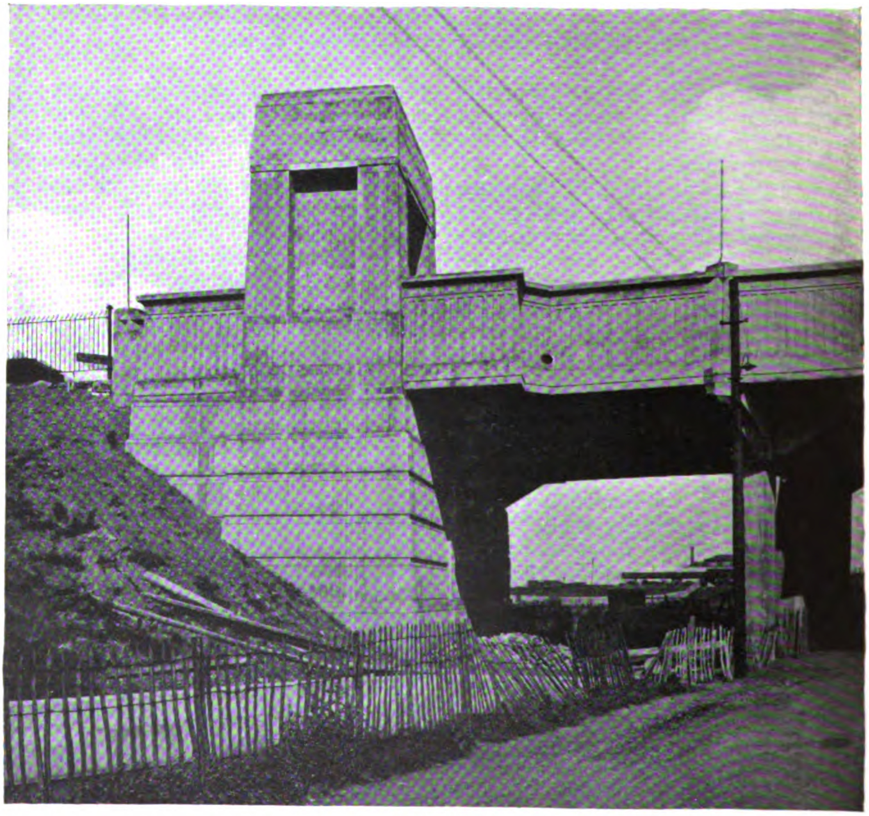
ase bars were left projecting from the ide span beams well into the centre span to which the future bars for this span could be easily spliced.

Owing to the great length of the work it was thought necessary to provide an expansion joint and a complete severance of the work at two points. One of these joints occurs about 150 ft. from the west abutment and the other separates the viaduct and bridge. At these points a double group of columns has been introduced; both groups, however, are founded upon the same group of piles so as to avoid any unequal settlement of the two parts. The amount of separation provided between one portion and the next was 1 in., and since the work was carried out this has been found to be slightly in excess of the amount of movement actually taking place over these lengths due to changes of temperature. In order to avoid any inequality in the roadway surface at these joints, cast-steel dovetail expansion plates have been inserted to span the distance between adjoining portions of decking.

The solid parapets of reinforced concrete shown in section in *Fig.* 3 are of generous proportions, having a cope width of 14 in. and a thickness at the base of approximately 17 in. The total height from the soffit of the pipe-duct to the cope is 8 ft., which, allowing for the pipe-duct, gives a parapet height above pavement level of 4 ft. The outer face of the parapet is fluted, whilst that facing the roadway has a reeded surface. Expansion joints to the parapets have been provided at every other pier where lamp standards do not occur. The free ends of the parapet where they bear on the cantilevers are provided with a mat of asphalted felt on which to slide, and are tied back to the bridge just below pavement-level by reinforced concrete ties to prevent the possibility of their getting out of line.

The pipe-ducts on each side of the bridge and viaduct are approximately 7 ft. 6 in. wide in the clear, with a slab 7 in. thick reinforced with ½-in. bars spaced 5½ in. apart. This slab spans between the parapet beam and a ledge provided along the face of the outer main beams to the bridge, and is free to move under changes of temperature upon a felt mat along this ledge. A lining to the ducts of ¾ in. asphalte has been provided throughout the length of the bridge and viaduct, and the floor of the duct is laid to fall with weep pipes at intervals to drain off any water collecting in the ducts to the hopper heads and down pipes, which also run off the surface water from the deck itself. Some trouble was experienced with this lining at the main expansion joints, where it was found that





Figs. 5 and 5a.—West Abutment and Span over Jenkins Lane.

[Note the remarkable similarity between the architect's drawing, made before work was commenced, and the photograph of the finished work.]

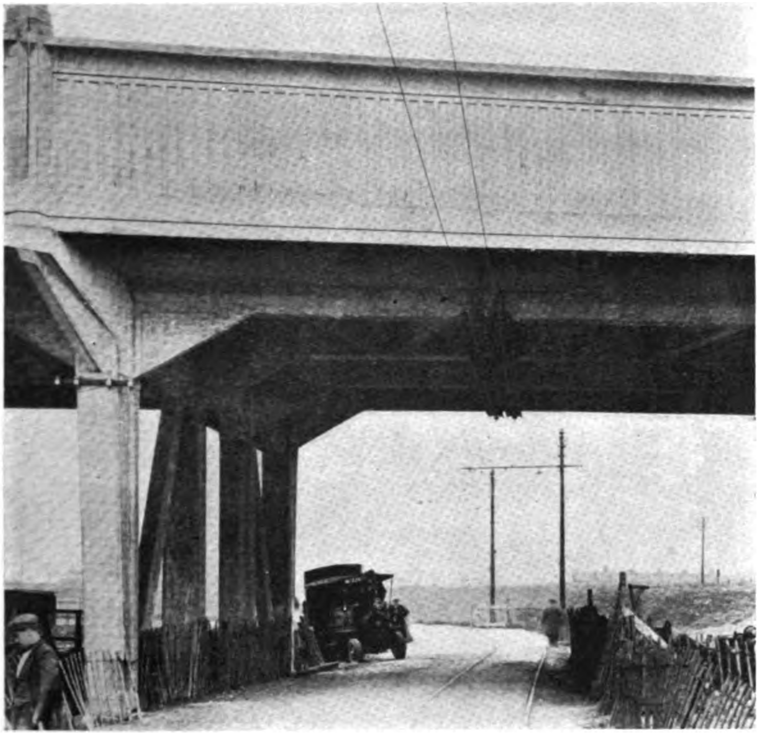


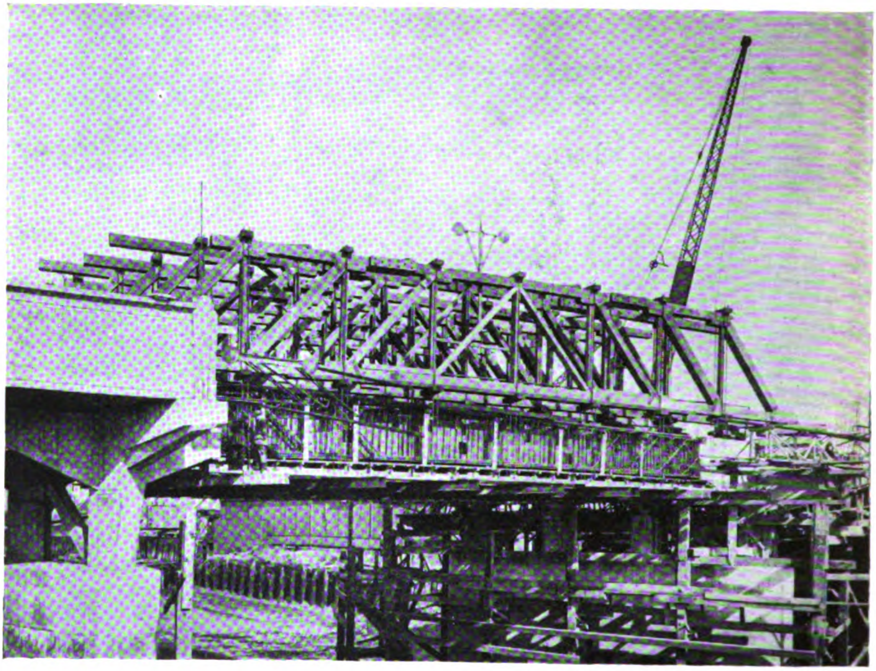
Fig. 6.—Underside of Span over Jenkins Lane.

the movement of the bridge under changes of temperature was too great for the elasticity of the asphalte; this resulted in cracking and the destruction of the watertight lining, and the difficulty was finally satisfactorily overcome by placing strips of expanded metal, bent into the form of an arch and embedded in the asphalte, to span these joints.

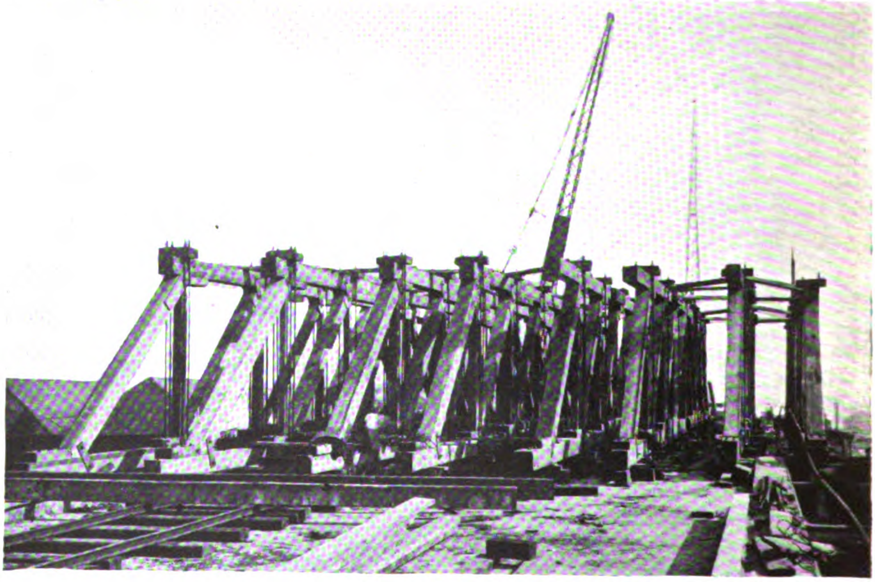
Owing to the requirements of the Port of London Authority that the centre span of the bridge be left open as long as possible, and that on no account could staging be allowed in this span during construction of the work, it was necessary to leave the concreting of this span of the bridge until last, and then recourse had to be made to the use of trusses to carry the falsework and concrete for this portion. Owing to the coal strike and the difficulty of obtaining steel sections it was decided to use timber for these trusses. These were accordingly designed to span the whole of the 80 ft. between centres of piers (*Figs.* 7 and 7a). The question of deflection was given great attention and special precautions were taken to make allowance for this so as to preserve an even soffit to the beams where they finally joined with the haunches at the columns which had been previously completed. Two trusses, erected above deck level, were employed for each main beam, the beam boxes being slung from the panel points of trusses by means of steel rods passing through the decking.

The lamp standards, twenty-two in number, were all pre-cast and transported to the site. These were provided with dowel bars set out to a template to drop into holes cored out in the parapet piers to receive them, and the holes were afterwards grouted up. A central tube running from the pipe-duct, up the parapet piers, and through the lamp standard provides for the electric lighting leads to the bronze lanterns above. An elevation and cross-section of these lamp standards is given in *Fig.* 3.

The angle piers to the pylons were cast

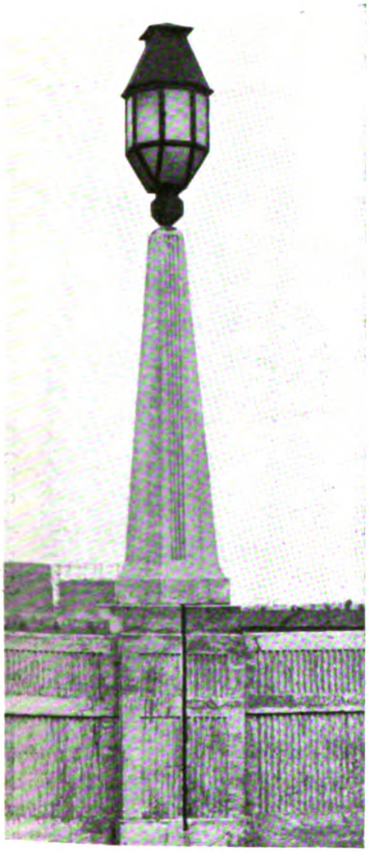


Side View.



End View.

Figs. 7 and 7a.—Temporary Trusses to Support Shuttering for 80-ft. Centre Span.



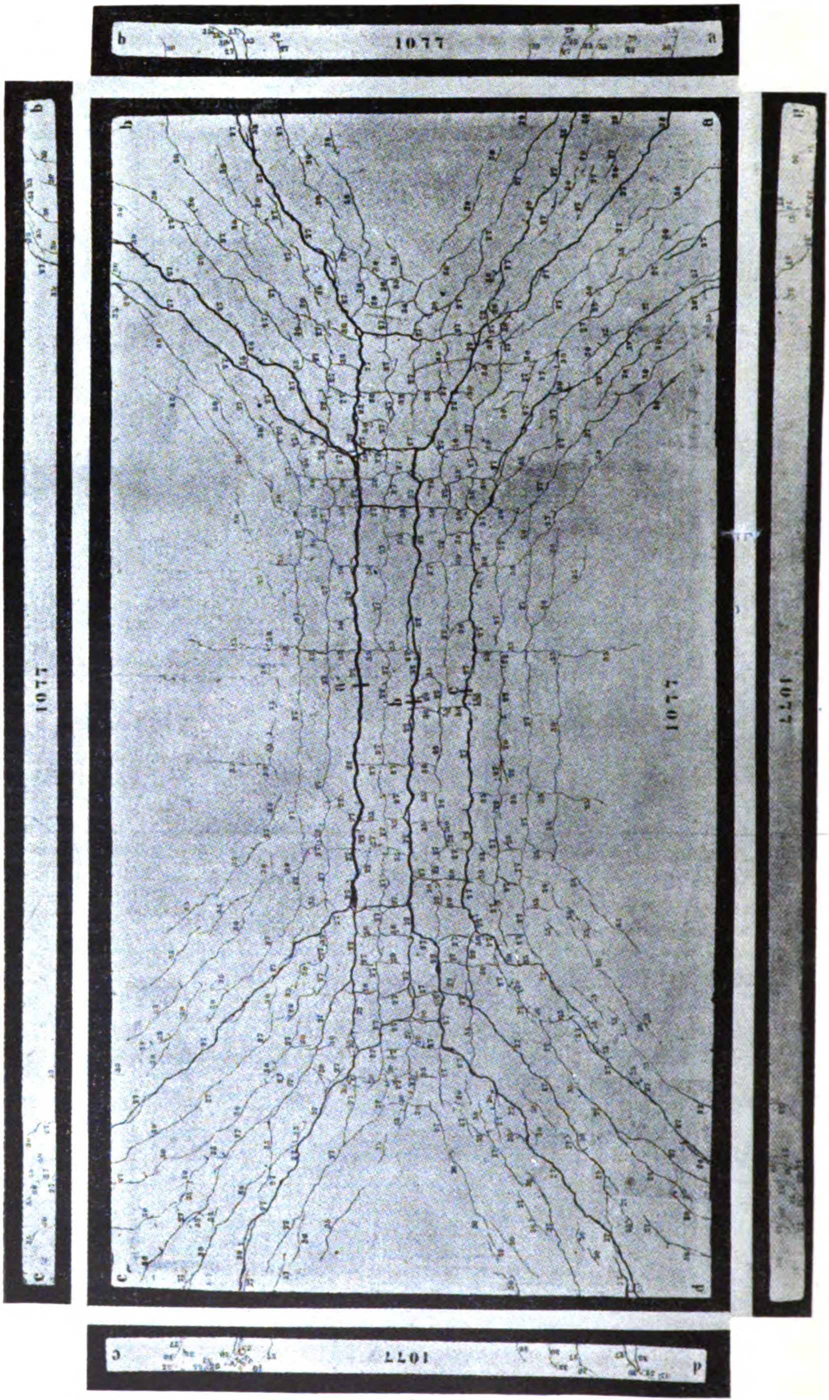
One of the Pre-cast Concrete Lamp Posts.

hollow, as was also the top. The height from pavement level to the soffit of the pylon is 12 ft., and the work for this height was concreted in a single lift in order to avoid any irregularity of surface.

The specification for surface finish of all faces exposed to view, whether reeded or not, required that no patching, trowelling, or rubbing down would on any account be allowed. If it was found on stripping that any surface showed signs of defect, the concrete was specified to be cut away to expose the steel and the face be recast.

It speaks well for the contractors that all the surface work has reached a very high standard, and but for a single exception no cutting back was necessary. Experiments were made upon the site to determine what mix and slump were required to give the best results with the various types of reeding employed, and these were rigidly adhered to throughout the work with correspondingly uniform results.

The bridge, for which Messrs. L. G. Mouchel & Partners Ltd., of 38, Victoria Street, S.W.1, were appointed executive engineers by the Ministry of Transport, forms a link in the new Barking By-Pass Road which comes under the direction of Mr. A. J. Lyddon, M.Inst.C.E., Chief Engineer of the Arterial Roads Department of the Ministry of Transport. Mr. Maxwell Ayrton, F.R.I.B.A., was responsible for the architectural treatment. Mr. H. S. Newmarch, A.M.Inst.C.E., acted as resident engineer, and the whole of the bridge work was carried out by Messrs. Walter Jones & Sons, Ltd. The concrete lamp standards were supplied by Messrs. Emerson & Norris, Ltd., and the bronze lanterns by Messrs. J. W. Singer & Sons, Ltd.



Tests on Full-Size Slabs. *(See p. 253.)*

Tests on Full-Size Slabs.

THERE has recently been published * an account of research work carried out at the Technical High School at Stuttgart on the strength of rectangular slabs of large scantling reinforced in different manners and submitted to uniform loading.

This small volume contains a very full account of Professor Graf's experimental work and is well illustrated with diagrams and photographs showing the slabs and the cracks which developed in them under increasing loads (see page 252).

The results of these tests, which are of considerable importance to reinforced concrete engineers, are summarised below.

Materials used in Specimens.

Gravel and sand from the Rhine were mixed with cement from the Nürtingen works which showed a resistance to compression of 5,150 lbs. per sq. in. after combined storage of 28 days (1 day in damp air, 6 days in water, and 21 days in air). The elastic limit of the 7 mm. rods used averaged 41,000 lbs. per sq. in. and the ultimate strength 60,000 lbs. per sq. in. All the concrete was mixed in the proportion of 1 part of cement to 5 parts of gravel and sand, by volume, with 10·1 per cent. of water by weight. In the finished concrete there were 515 lbs. of cement to each cubic yard.

At the time of testing the slabs and beams the resistance of the concrete to compression was tested on cubes with the following results :

Slab No. .	1077	1079	1081	1083	1085
Age (months)	19	19	23	20	18
From (lbs.in.^{2})	4,420	4,160	4,190	4,800	5,000
To (lb.ins.^{2}).	4,080	4,190	3,950	4,720	5,090

Average = 4,450 lbs. per sq. in.

The strength on prisms was about 79 per cent. of that on cubes.

Description of Specimens.

Five slabs in all were cast, each being 13 ft. 7 in. long, 7 ft. 1 in. wide and 4¾ in. thick. These were reinforced as follows :

Slab 1077.—Equal, equidistant mesh in both directions with the shorter bars underneath. Ends of bars hooked round a 1½-in. mandrel with a 2 in. tail. Cover on bars, 0·4 in. Diameter of bars, 7 mm. Weight of steel = 122 lbs., or 12·7 lbs. per sq. yd.

Slab 1079.—Same steel except in the longer direction where there are eleven 7-mm. rods at 8-in. spacing, instead of twenty-one at 4 in. Weight of steel = 94 lbs., or 9·8 per sq. yd.

Slab 1081.—As before for bars parallel to short side, but with six 7-mm. bars at 12 to 18 in. parallel to the longer side. Weight of steel = 80·2 lbs., or 8·4 lbs. per sq. yd.

Slab 1083.—As before for bars parallel to shorter side, but with five 5-mm. rods parallel to the longer side. Weight of steel = 71 lbs., or 7·4 lbs. per sq. yd.

Slab 1085.—7-mm. bars at 2·2 in. centres parallel to the shorter side, and with eight 5-mm. bars at from 11·0 to 11·4 in. centres parallel to the longer side. Weight of steel = 127 lbs., or 13·2 lbs. per sq. yd.

In addition to the slabs five beams were cast each being 7 ft. 1 in. long, 1 ft. 8 in. wide and 4¾ in. deep. These were tested on a 6 ft. 3 in. span. The reinforcement was similar to that in the slabs, and all were tested under uniformly distributed loading.

RESULTS OF TESTS.

Loading at first crack and failure.

Slab No.	lbs.	lbs.
1077	34,000	77,000
1079	39,600	68,100
1081	35,200	63,900
1083	47,200	61,500
1085	47,200	106,000

The first crack appeared in all the slabs in the middle part of the undersurface (see "c," page 252).

Beam No. .	1078	1080	1082	1084	1086
Load at first crack (lbs.)	3,750	4,400	4,400	4,510	5,060 lbs.

In the test of slab No. 1077 a second crack appeared at "b" under a load of 44,000 lbs. At 48,400 lbs. the lengths of the cracks increased, that at "a" becoming 7 ft. 6 in. Most of the cracks were then parallel to the long side but some ran in the direction of the corners at an angle of 45 deg. At a load of 66,000 lbs. the crack "a" was 0·06 in. wide.

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* *Versuche mit allseitig aufliegenden rechteckigen Eisenbetonplatten.* By O. Graf. Berlin : W. Ernst & Son. Price R.M. 6.90.

Ratios of maximum load to total weight of steel for the slabs tested.

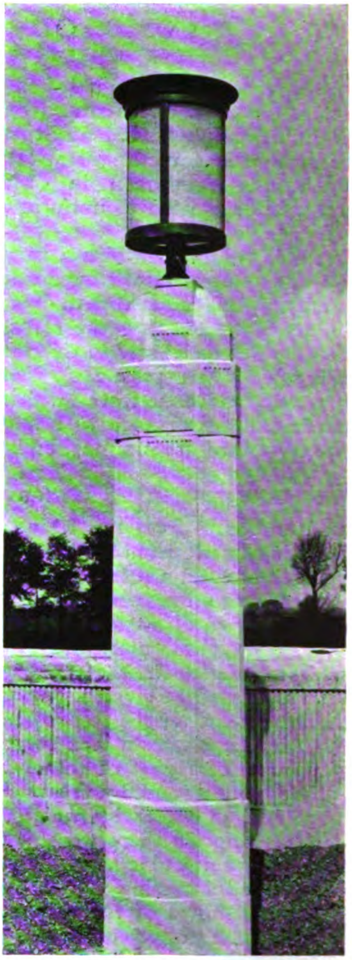
Slab No.	Ratio.
1077	628
1079	726
1081	794
1083	870
1085	830

These figures represent the load carried, by similar slabs, differently reinforced, by each pound of steel, and may be called the relative efficiencies of the slabs for ultimate loads.

The elastic and permanent deformations of the slabs were also measured at many points.

It will be seen from the illustration that the mesh-reinforced slab No. 1077 (i.e. one having equal steel per foot-run in both rectangular directions), in which the first crack appeared at a load of 34,000 lbs., did not develop cracks along the lines bisecting the angles at the corners until the load reached nearly 1½ times that required to produce the first crack in the slab centre, parallel to the long axis of the slab. This is at variance with the basis of a commonly-used method of design in which it is supposed that the cracks start simultaneously at all points of the ultimate broken boundary of the slab, i.e. the figure formed by the bisectors of the angles and a line through the long axis of the slab.

The results of Professor Graf's researches indicate that the design of mesh-reinforced slabs as commonly carried out is open to question. A comparison of the loads producing first cracks shows that slabs No. 1079 and 1083 supported higher loads than slab No. 1077 which had heavier reinforcement in the longitudinal direction. From these results one is inclined to question whether the value of mesh reinforcement has not been over-rated in the past. It is not advisable to be dogmatic on the results of a limited number of tests, however carefully they have been carried out, but plainly there is some doubt concerning the value of reinforcement placed parallel to the long axis of a rectangular slab. The practice of some designers who insert steel running in what may be called *unnatural* directions and assume that such steel takes a load in these directions seems to be disproved by these experiments.—W. S. G.



[*Made by Emerson & Norris, Ltd.*

Cast Stone Lamp Standard.
Mr. Maxwell Ayrton, F.R.I.B.A., Architect.

Reinforced Concrete Cathedral at Demerara.

By HERBERT E. STEINBERG, M.Inst.C.E.

EARLY in 1914, the late Leonard Stokes, PP.R.I.B.A., was invited to visit Demerara, British Guiana, in connection with the re-building of the Roman Catholic Cathedral, the original structure having been destroyed by fire.

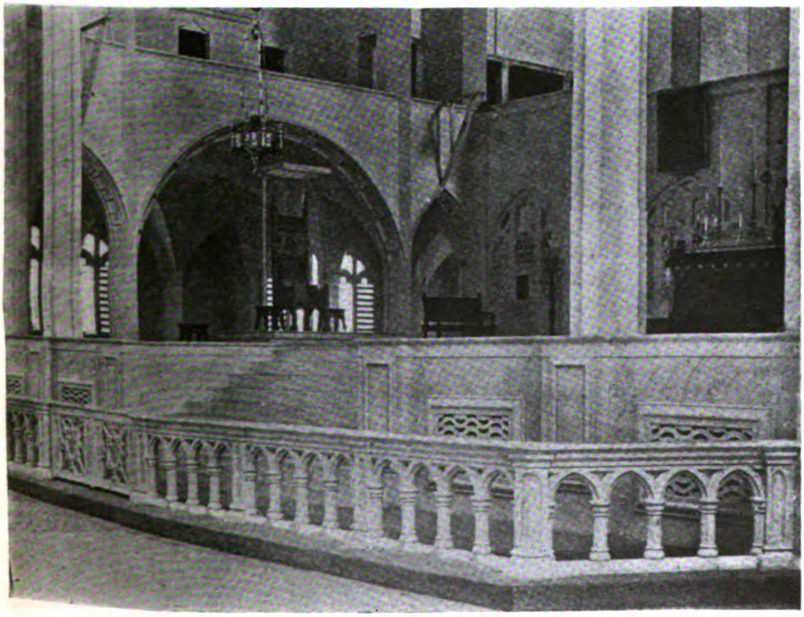
From the information available as to the quality of the soil it appeared that there might be some difficulty in providing adequate foundations, and the writer was asked to accompany Mr. Stokes as advisory engineer. The adoption of reinforced concrete piles had been suggested, but on arrival in Georgetown, and after full investigation, it was found that the use of piles for supporting buildings in this part of the Colony had not been particularly satisfactory owing to the nature of the soil, which consists of a waterlogged silt of very considerable depth.

From information obtainable, and observations made of existing buildings, it was considered that the surface of the ground might safely be loaded to half a ton per sq. ft. So small a ground pressure made it impossible to design the Cathedral in any other permanent material except reinforced concrete, and even with this there was considerable difficulty in reducing the thickness of the walls, etc., sufficiently to keep the ground pressure within the agreed limit.

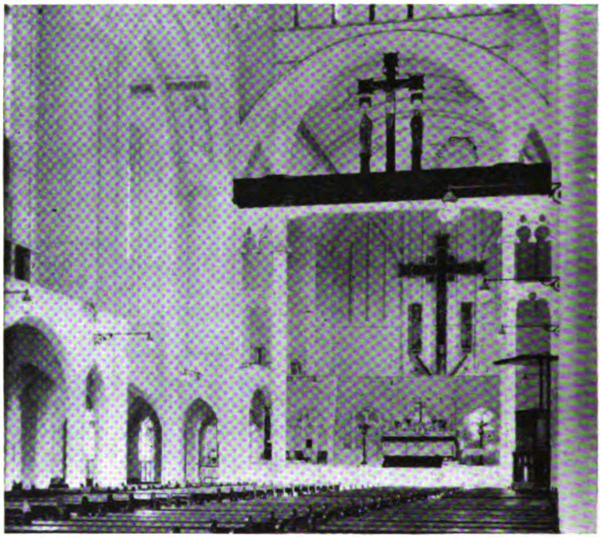
In consequence, it was necessary to spread the weight of the superstructure over the whole area occupied by the Cathedral, and this was accomplished by means of a reinforced concrete cellular raft, the bottom slab of which rests on the surface of the ground and the top slab forming the floor of the Cathedral, the total height of the raft being about 6 ft. With the object of keeping the ground pressure as uniform as possible all over the area of the site, panels in the bottom slab of the raft were deleted in those parts of the building loaded less heavily than the portion under the tower.

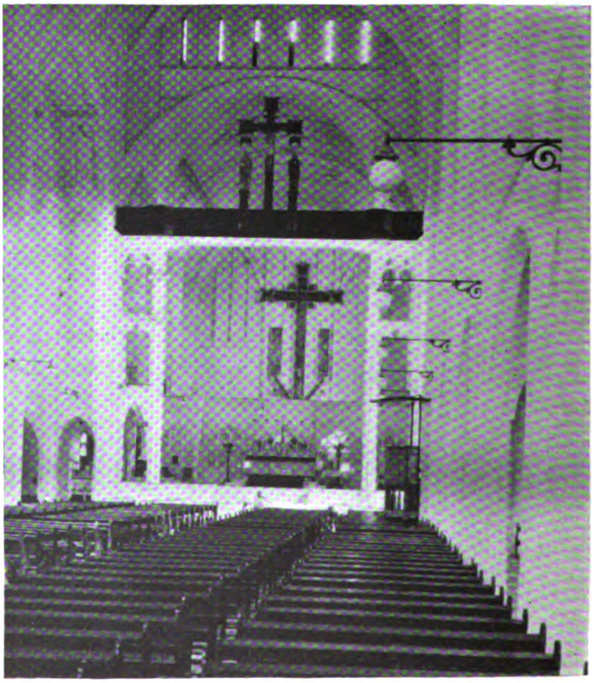
The actual construction was delayed considerably by the war, but the main part of the work is now complete and the photographs show the appearance of the interior.

In the twelve years which have elapsed

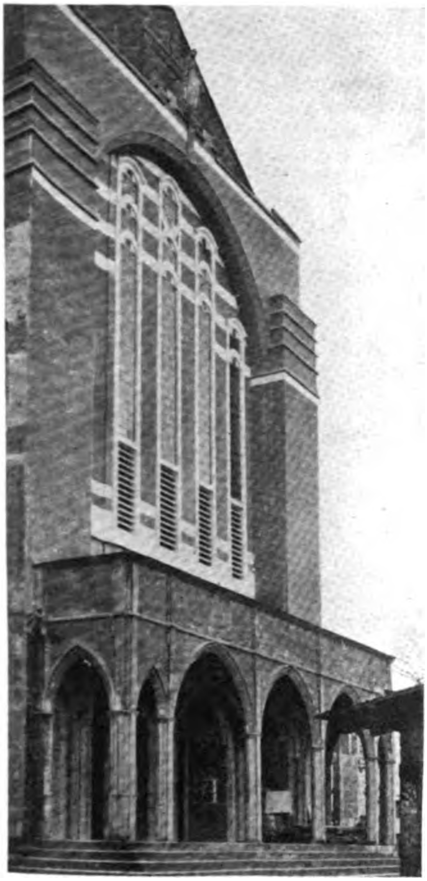


Georgetown Cathedral, Demerara: Interior View.





Views in Georgetown Cathedral, Demerara.



An Exterior View of Georgetown Cathedral, Demerara.

since this building was designed the advantages of reinforced concrete have become more generally recognised by architects, and its adoption has enormously increased. Credit should therefore be given to Mr. Stokes for his boldness in utilising reinforced concrete for so important a work, and also on account of the use of concrete made of white Portland cement. This was employed for the mullions and tracery in the windows, and for a large part of the interior of the Church. Coloured concrete in red and black squares was also adopted for the floor of the Cathedral.

The writer has just returned from a visit to the West Indies, and took the opportunity of making a close inspection of the new building. With the exception of the west front, the exterior surface has been left as from the shuttering, and in consequence does not give a true idea of what the finished appearance will be. The Cathedral has, however, been open for services for some time, and the interior is practically complete with the exception of a small amount of surface rendering to be done at certain points.

The whole of the internal work is also in reinforced concrete, and finished with white Portland cement. The system of natural ventilation requires a large number of grids of different patterns, all of which are in white Portland cement concrete, extraordinarily well carried out. The slats of the louvres underneath all the windows are also in the same material. The appearance of the inside of the Church is most impressive. It is light, airy and spacious, but, at the same time, full of a quiet religious feeling.

The work at present is finished up to the level of the base of the tower, and it is hoped to recommence work this year (if funds permit), and complete both the tower and the spire. Reinforcing bars have been left projecting from the concrete already deposited to form the necessary connection.

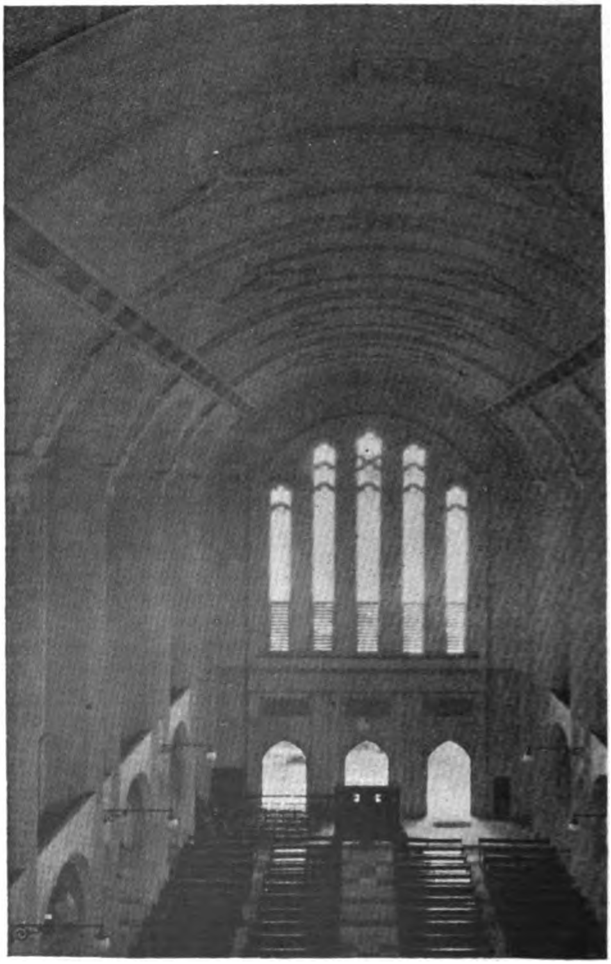
A close examination of the entire structure from top to bottom failed to reveal any cracks either in the raft or the superstructure, and there appears to be no reason why the Cathedral should not last indefinitely without any expense on upkeep. The coloured pigments used for the surfacing of the floor have, however, not always been entirely satisfactory. The red pigment used for certain panels in the floor at the west end has apparently, in six years, caused the cement to disintegrate. The use of this colour was therefore abandoned in the later part of the work.

The details of the reinforced concrete work for such a structure were necessarily complex, and the working drawings showing the location of the reinforcing bars, which were prepared by Messrs. Considère Constructions, Ltd., had to be construed by black labour totally unaccustomed (at the beginning of the job) to this class of work. The raft was carried out by a local contractor under the efficient supervision of a Scotch clerk of the works, but the superstructure was built by direct labour employed by the

Church authorities and directed by Mr. A. Walker. The result could not be bettered in this country, even if built by a firm of contractors specialising in reinforced concrete, and the Cathedral demonstrates conclusively the suitability of reinforced concrete work for bridges and buildings abroad.

The necessary materials are easily shipped: minor alterations can be dealt with on the site, and the work, when finished, is absolutely permanent and requires no maintenance whatsoever, whatever the climatic conditions may be. It is, of course, necessary for good stone and sand to be available on the site at reasonable prices, and it is absolutely essential for a competent clerk of the works, highly trained in reinforced concrete construction, to be in charge of the operations.

Difficulties will, of course, be met with at the commencement of the job in training the native labour, but these rapidly disappear as the work proceeds, and the fact that no expensive plant or tackle is required for lifting heavy weights is a point of great importance. Judged by European standards the native labour is undoubtedly inefficient, but this is compensated for by the lower rates of wages.



Interior View of Georgetown Cathedral, Demerara.

Pile Foundations.

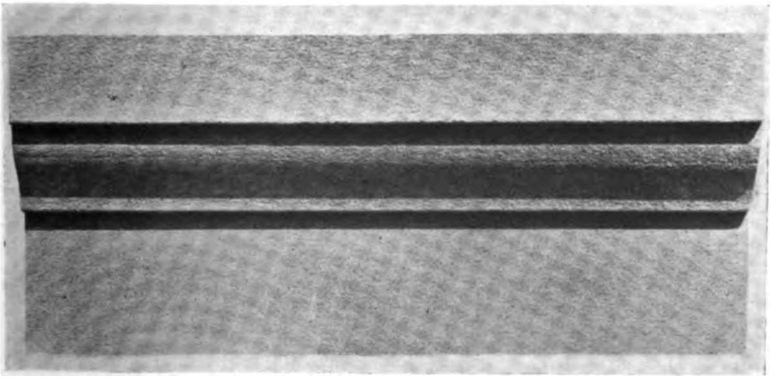
THE following is abstracted from a paper, by Mr. J. P. Porter, B.Sc., A.M.Inst. C.E., to be brought forward for discussion at the Institution of Civil Engineers. The paper deals with the solution of the particular problems involved at the points where the Watford Branch, Metropolitan Railway, and the Watford By-Pass Arterial Road, cross the valley depressions which practically surround Watford.

The author discusses the investigation of site conditions by means by trial piles, and considers the bearing value of piles, showing that this may be derived from piling formulas in the case of friction-supported piles only. Such formulas are of no value for piles acting as columns; and the "quality" of the supporting force may be deduced from the pile-driving charts. The bearing value of pile groups relative to the bearing values of the individual piles is also considered.

Factors limiting the utility of piling formulas are considered, the most important of these being that the bearing value immediately after driving bears no fixed relation to the bearing value after the sub-soil has had time to settle around the pile. The author recommends that trial piles be driven in stages to allow the true bearing value to be estimated.

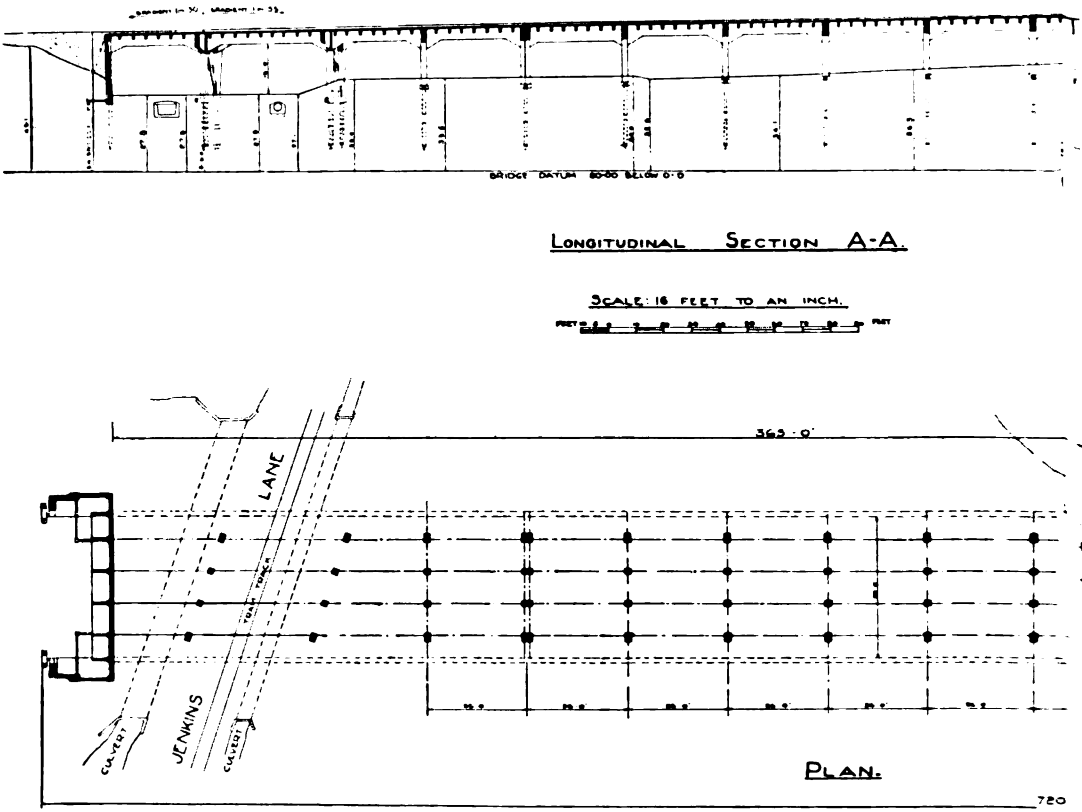
Regarding the form of a piling formula, the author is of the opinion that this should be an expression of the estimated ultimate resistance to driving after an interval for settlement of the sub-soil; and that the designing engineer should select the factor of safety to be applied, having due regard to the various factors involved. Considering the design of friction-supported piled foundations in general, the author believes that the collection of fully recorded data of many carefully conducted investigations is the most rational method of solving the problem; and he urges the appointment by the Institution of a "Committee on Design" charged with the collection and publication of accurate records in connection with this and other such mathematically indeterminate problems. These include the lateral support afforded by sub-soil to piles butting on rock and acting as columns, and the skin-friction resistance to the sinking of monoliths.

Proceeding to the consideration of deep foundations, he shows that foundations depending on bearing action are to be preferred to foundations utilising frictional support; and that in the placing of deep foundations the overcoming of skin-friction pressure is one of the principal problems. He indicates that, where they can be used, monolith foundations, excavated preferably "in the dry," are an efficient type of foundation; and that such foundation will be relatively economical if the monoliths are so designed that they sink under their own weight. This condition will be fulfilled if the weight of the partly completed monolith is always sufficient to overcome the frictional resistance to sinking.



[*By Emerson & Norris, Ltd.*

Cast Stone Moulding: Cast in Sand.

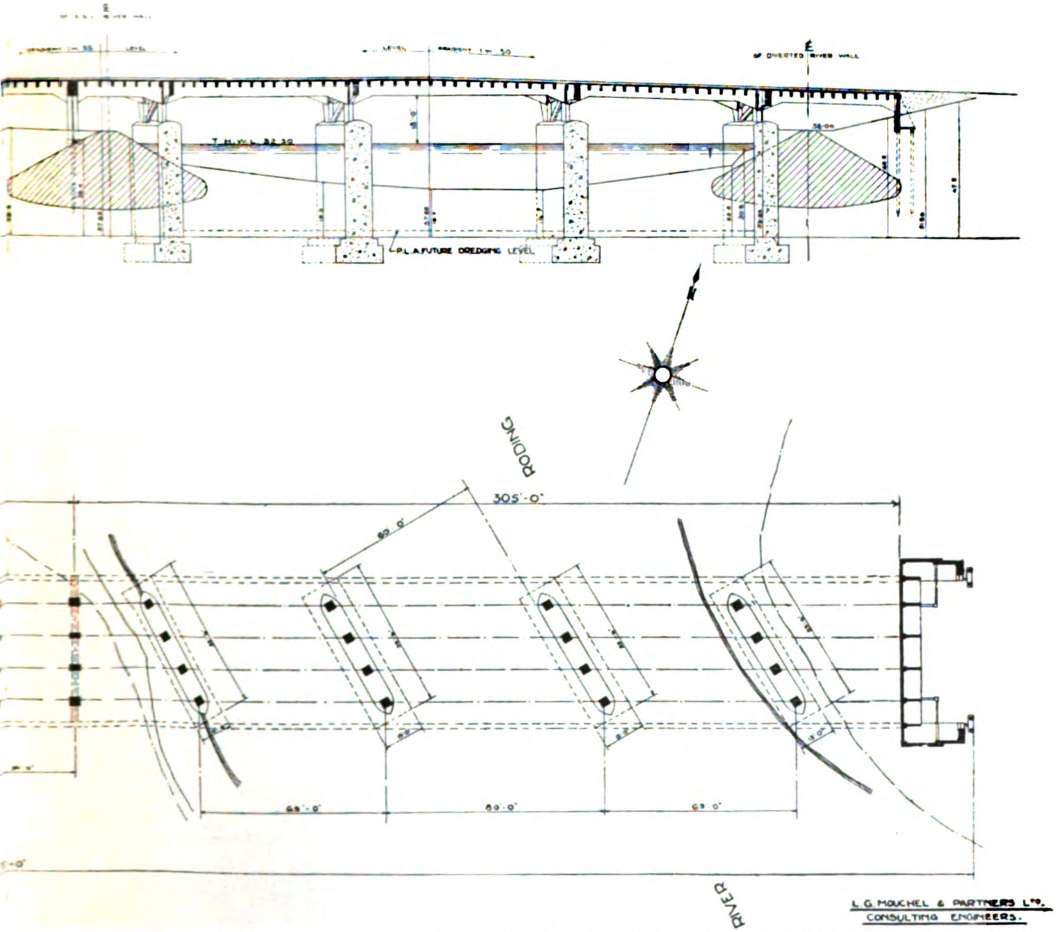


Longitudinal Section A-A.

Scale: 16 feet to an inch.

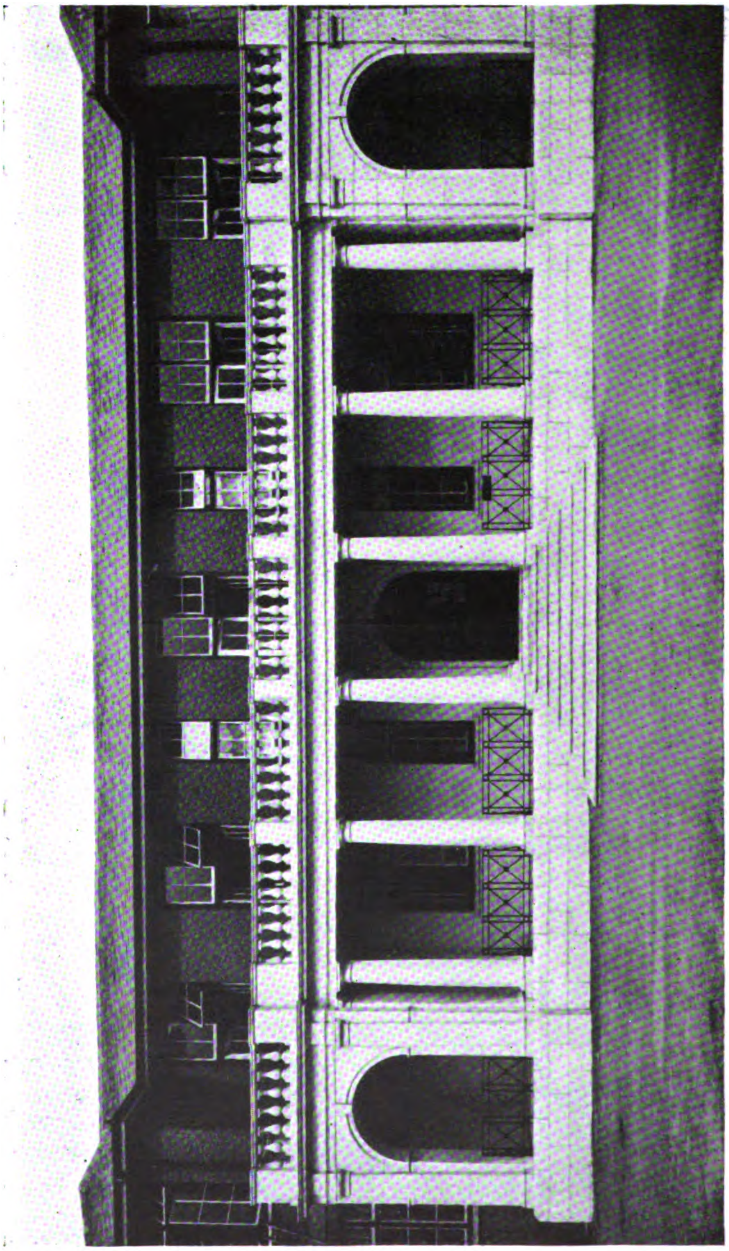
Plan.

REINFORCED CONCRETE BRIDGE AN



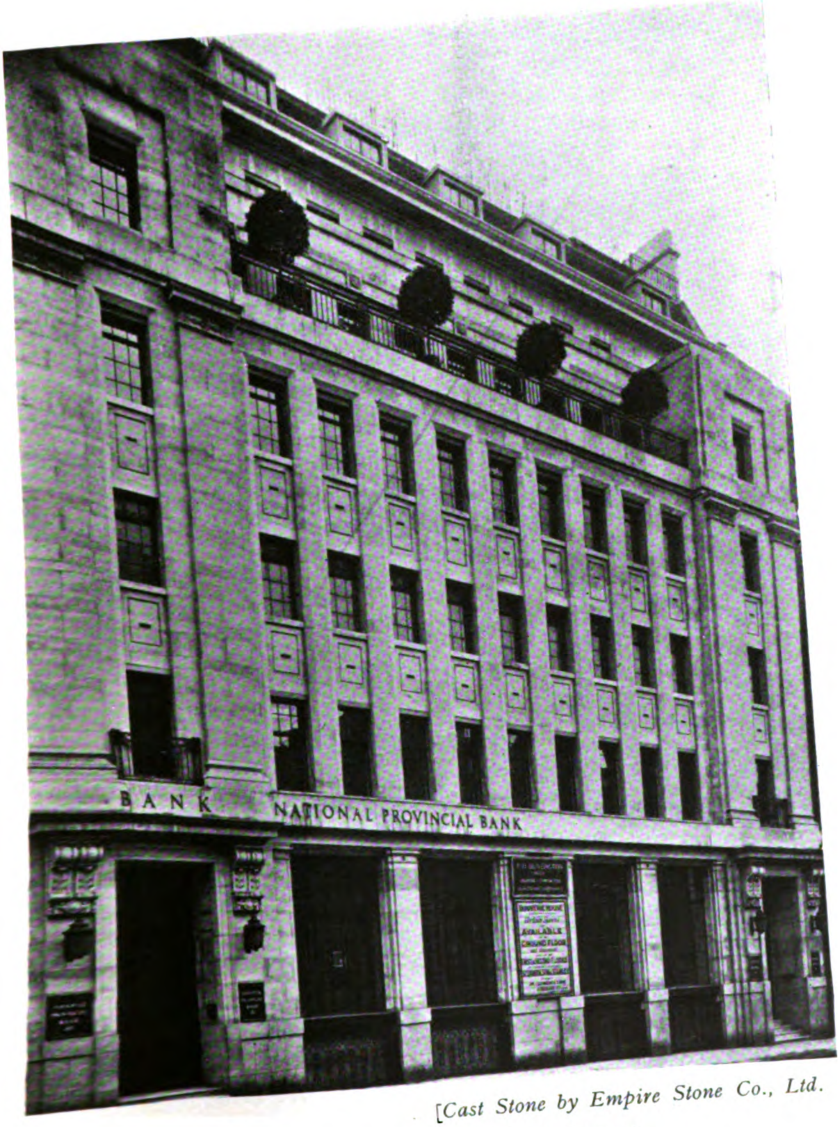
[*Reinforced Concrete Design by L. G. Mouchel & Partners.*

VIADUCT AT BARKING. (*See p.* 243.)



[*Cast Stone by Empire Stone Co., Ltd.*

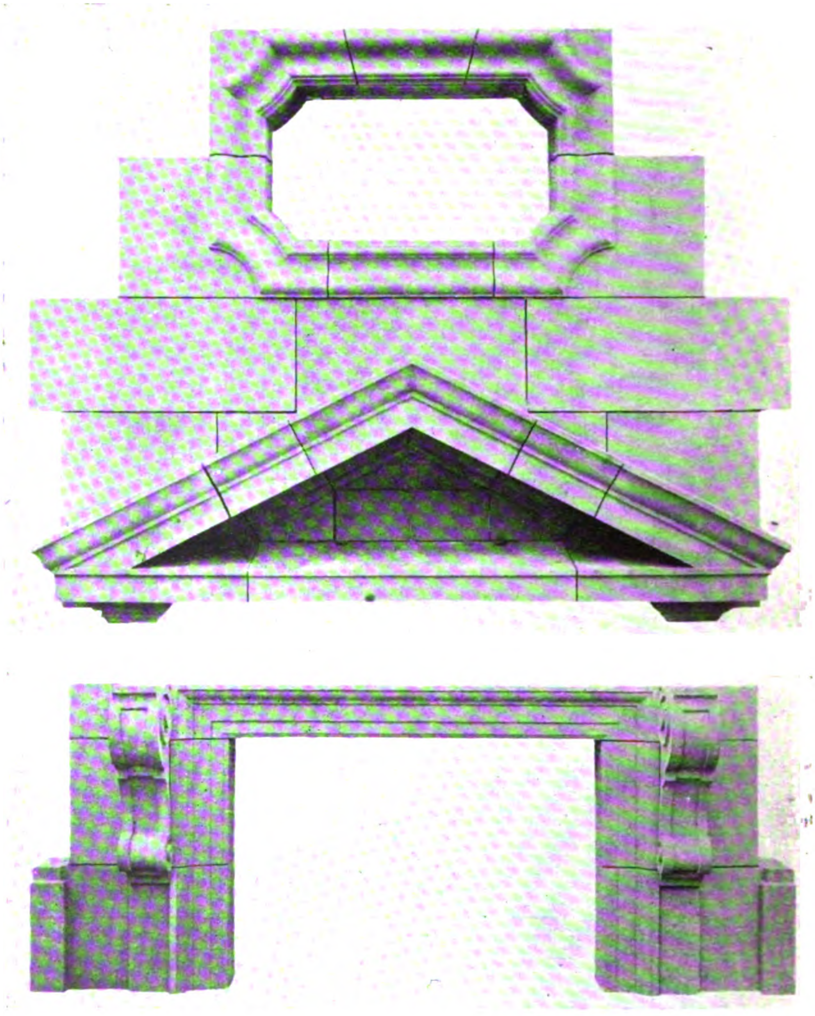
Cast Stone Loggia to Sports Ground Pavilion.



[Cast Stone by Empire Stone Co., Ltd.

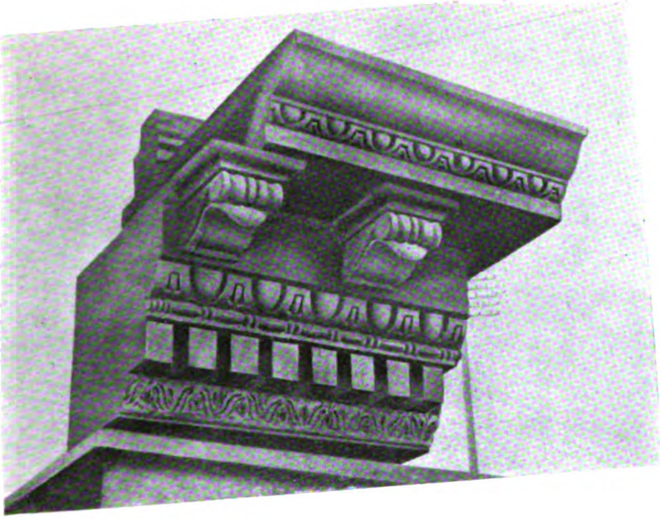
Bouverie House, Fleet Street.

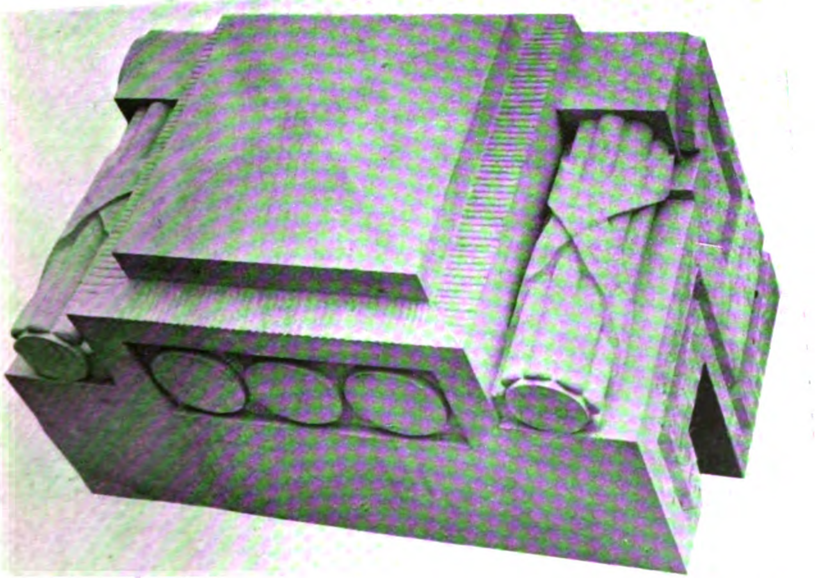
[One of London's most recent cast stone elevations.]



[*By Stuart's Granolithic Co., Ltd.*

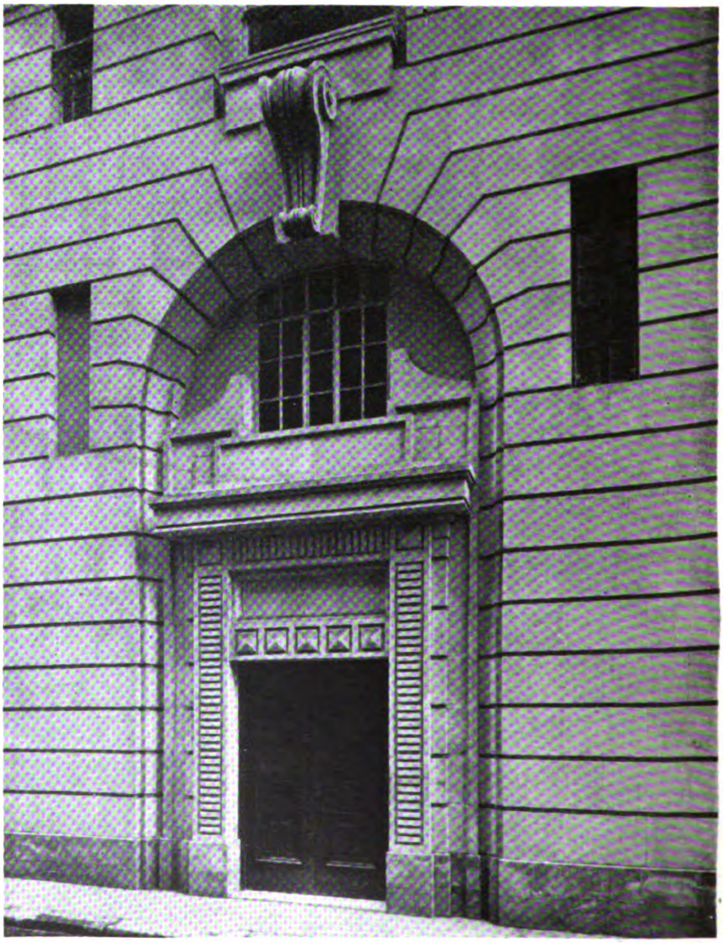
Part of Doorway in Cast Portland Stone for a City Building.





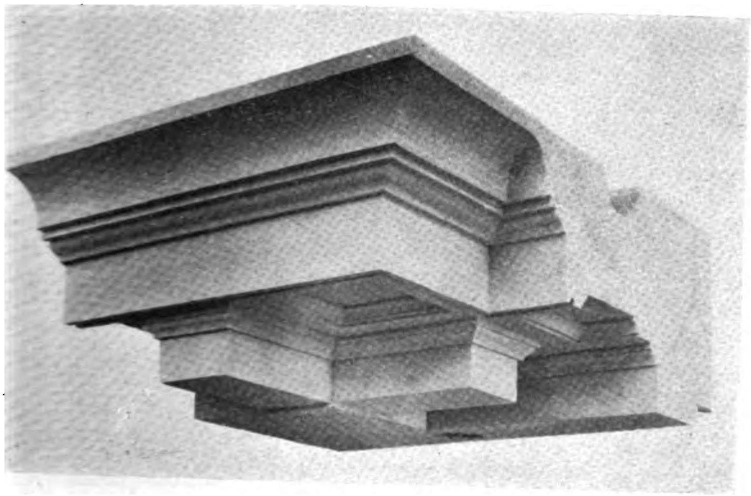
[By Stuart's Granolithic Co., Ltd.

Architectural Work in Cast Portland Stone.

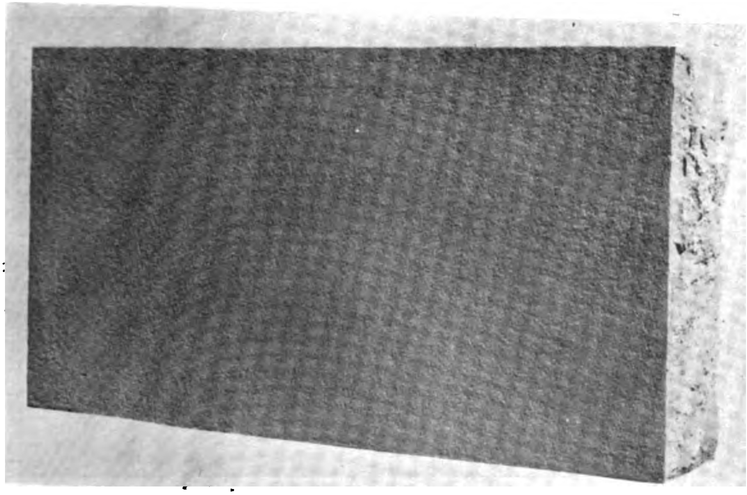


[*Cast Stone by Empire Stone Co., Ltd.*

Cast Stone Doorway at Conservative Club, St. James's.

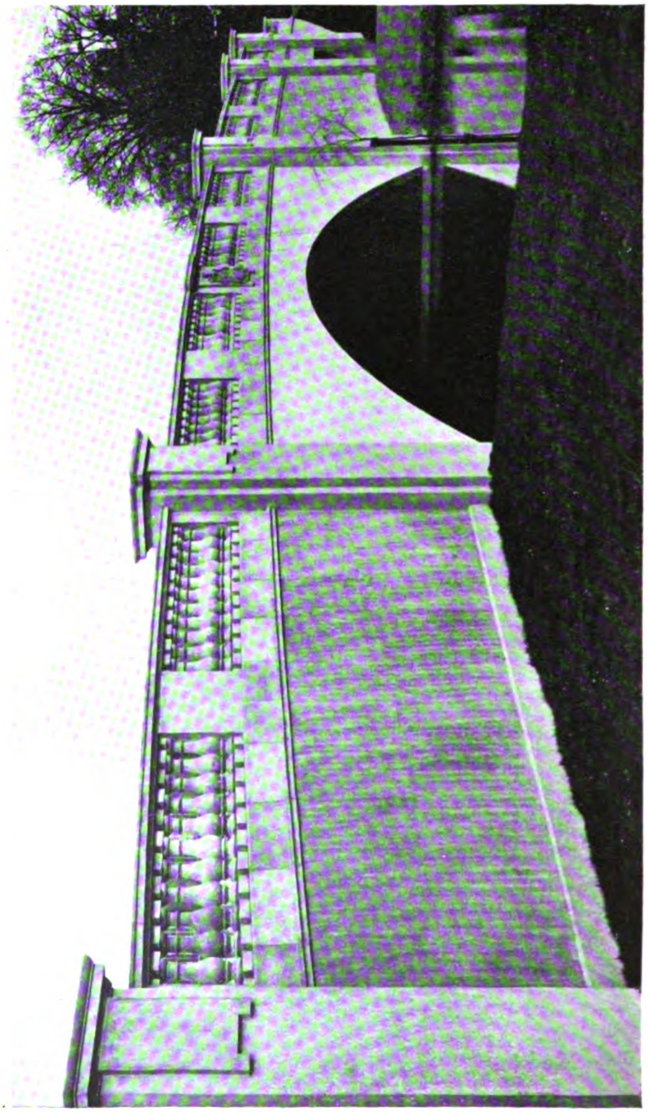


Section of Cornice.



[By Emerson & Norris, Ltd.

Cast Stone Moulded in Sand, showing Surface Texture.



[*Cast Stone by Cambridge Artificial Stone Co., Ltd.*

Reinforced Concrete Bridge at Cambridge with Cast Stone Balustrade.

Raising a Reinforced Concrete Coal Bunker.

In the course of a paper read before the Society of Engineers last month, Mr. M. E. Gerard gave some interesting particulars of the method of raising a 1,250-ton coal bunker that had settled 7 ft. at one end owing to subsidence.

The bunker in question was one of two that had been built to provide storage for 2,500 tons of coal on a tidal riverside site, with direct loading into barges. Each bunker is 143 ft. long, 27 ft. wide, and 21 ft. from cope level to the bottom of the bins. A space of 21 ft. 6 in. was provided between the bunkers, bridged at the top to allow the passage of cranes from one bunker to the other.

Fig. 1 shows the general plan of the coal-handling plant. It being desired to bring barges directly under the bunkers, it was arranged to have, on a transverse section, supports only under the walls, leaving a clear space of 20 ft. between the fenders for the barges, as shown in *Fig.* 2. Each bunker was provided with only eight supports at 47 ft. 6 in. centres (*Fig.* 1).

The load estimated to come upon the supports at each corner was slightly under 250 tons, and that supported by each of the four intermediate supports slightly under 450 tons. The borings revealed strata of 2 ft. of mud overlying a bed of compact gravel 7 ft. thick; then a layer of 5 ft. of softish clay in which trial piles travelled at the rate of 1 in. for 3 blows of a 2-ton hammer with a 2 ft. 6 in. drop; and finally a layer of hard blue clay extending down for at least 17 ft. The foundations were designed to consist of groups of reinforced concrete piles 14 in. by 14 in. about 25 ft. long, driven into the ground for about 20 ft. After driving, the upper 24 in. of concrete were removed so that the pile bars could be built into the concrete piers in the usual manner. There were 7 piles under each intermediate pier, and 4 piles under each corner pier.

The piles had been specified to be driven until the set did not exceed ½ in. for the last 10 blows of a quick-acting 2-ton hammer with a drop of 2 ft. 6 in. The set obtained in practice varied from ¼ in. to ½ in., but never exceeded that figure, and it was confidently expected that each pile would carry at least 65 tons with a factor of safety of 4 to 5.

Soon after completion of the first bunker, and while the work was proceeding upon the second bunker, filling with coal was proceeded with. After a few hundred tons had been bunkered, a settlement of between ⅜ in. and ½ in. was noticed at the downstream end, but no great importance was attached to the fact. The bunker was kept under observation, and it became evident that settlement was really taking place, reaching 2 in. when the load was about 600 tons. When about 1,000 tons had been bunkered the downward movement began to accelerate, and within two hours one end of the bunker had sunk 7 ft. and then stopped, the level of the upstream end remaining practically unaltered. A slight tilting of about 9 in. toward the shore side had also taken place.

In reinstating the work, the first operation consisted of releasing all the coal stored and in securing in position the

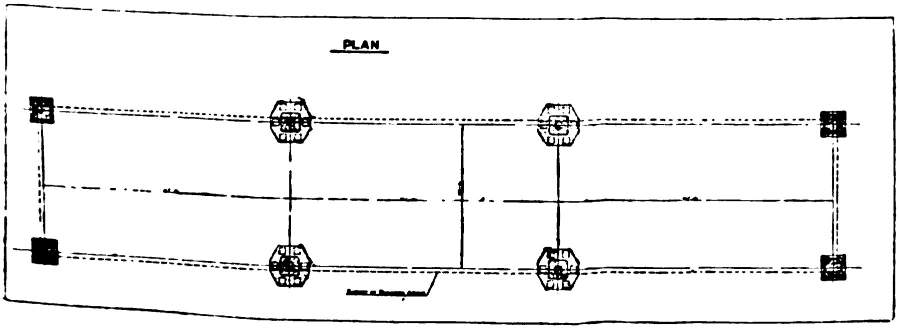


Fig. 1.

heavy travelling cranes which ran along the top of the bunkers. The whole structure remained uninjured during the movement, and inspection failed to reveal any crack in the wall or floor of the bunker. The only cracking found was at the junction of the upstream pier with the quay; this point, which had not sunk, apparently acted as pivot during the movement. The top of the downstream end-wall got out of plumb by about 34 in. lengthways and about 9 in. laterally toward the quay frontage. In order to counteract any possible (although unlikely) tendency to overturn further, shoring was resorted to as well as the local conditions permitted.

The excellent behaviour of the reinforced concrete under the heavy stresses to which it was no doubt subjected during the sinking gave reasons to believe that the structure would withstand successfully the process of raising and bringing back to its original level. It was estimated that demolition and rebuilding the bunker would have cost about £20,000, whereas about £8,000 was expected to cover the cost of raising and reinstating, and the latter would save time. A study of the cause of the subsidence having satisfied the engineers, Messrs. L. G. Mouchel & Partners, Ltd., that it was possible to form a safe foundation for the reinstated bunkers, the owners decided to follow their advice.

In view of the very uneven sinking, the stresses during the raising would not all be vertical; horizontal stresses also were expected. Further, as the heavy part of the structure was at a great height above the bottom of the river (36 ft.) the stresses were bound to be unequally distributed and the bracing of the supports presented difficulties. It was felt that this combination of circumstances rendered it somewhat risky to provide temporary trestles of timber or of steel. There was in addition difficulty in obtaining suitable steel sections. Consequently reinforced concrete was considered to be the more suitable and safer material. No delay was to be experienced in waiting for the concrete to harden, as it was decided to use aluminous cement for the construction of the trestles, thus enabling the trestles to be used for raising the structure 24 hours after their completion.

It was ultimately resolved to erect 8 ferro-concrete trestles. Four of Type A (*Fig.* 3) to be as near as possible to the corner piers; and four of Type B (*Fig.* 4) to be erected one around each of the 4 intermediate piers. On each of the trestles A were set two hydraulic jacks, each able to lift 150 tons; and on each trestle B there were four similar jacks. All told there were 24 jacks, together able to lift a load of 3,600 tons. As the weight of the bunkers proper, after severance from the supports, and stripped as they would be of all the machinery for operating the sluices of the chutes, etc. (but including the weight of the two travelling cranes weighing about 45 tons each, which were at work upon Bunker No. 1, and which it had been decided not to dismantle during the process of raising the bunkers), was slightly under 1,600 tons, each jack would be used to lift an average of only 70 tons. The margin was sufficient to allow for the unavoidable excess load which might come now and then upon some of the jacks while others were not raising their full share. Three extra jacks were provided in case of emergency. Some of the jacks were provided with pressure gauges.

Owing to the considerable inclination of the bunker it was desirable to take every precaution against the possibility of the whole structure pitching forward after the supporting columns had been cut through for the purpose of lifting. Although there was not much likelihood of this happening with the massive and stable arrangement of temporary trestles adopted, it was considered advisable to anchor the bunker back to the bases of some of the columns of the second portion of the bunker by means of strong steel cables. Screw attachments were provided, and men were in attendance to keep the cables thoroughly tight during the process of raising, thus helping to pull the structure back to its original position.

The design of the trestles of Type A does not present any special feature. The foundation slab was designed to reduce the load on the gravel bed of the river to a stress not exceeding 1·5 tons per sq. ft. The projecting parts on *Figs.* 3 and 4 were to keep in position the packing pieces which were to be gradually inserted between the trestle and the rising structure. It was very necessary that this packing (which had to be built up to a considerable height, especially in the cases near the downstream end) should be in some way wedged up and held securely to the trestles. Had provision not been made for this disastrous results might have occurred towards the latter part of the lifting, with the huge mass of the bunker supported entirely on loosely built grillages many feet in height. These projections also afforded a means for the attachment of a platform for the men working the jacks, etc., which could be raised as required during the lifting process. The stroke of the jacks was 6 in., and consequently it was necessary, after working the downstream end jacks up to 6 in., to pack up the structure, release the pressure, pack up the jack nearly 6 in. and start the operation again.

Fig. 5 shows the various stages of the lifting and the gradual packing, both under the jacks and under the short joists which held the structure during the preparation made to raise the jacks. It will be observed that in order to allow the free passage of the longitudinal bracing some 7 ft. below the bottom of the bunker wall, the upper end of the trestles had to be severed into two parts, thus somewhat complicating their design. Obviously, the intermediate jacks had to have a smaller movement at each operation, but similar arrangements had to be made for packing on every trestle. Hence the provision in every case of the projecting parts.

The design of the trestles of Type B presented a rather curious feature. The trestle was designed so as to surround an intermediate pier of the bunker, the latter occupying the axis of the trestle. The foundation slab of the trestle was utilised as part of the new foundation to the pier,

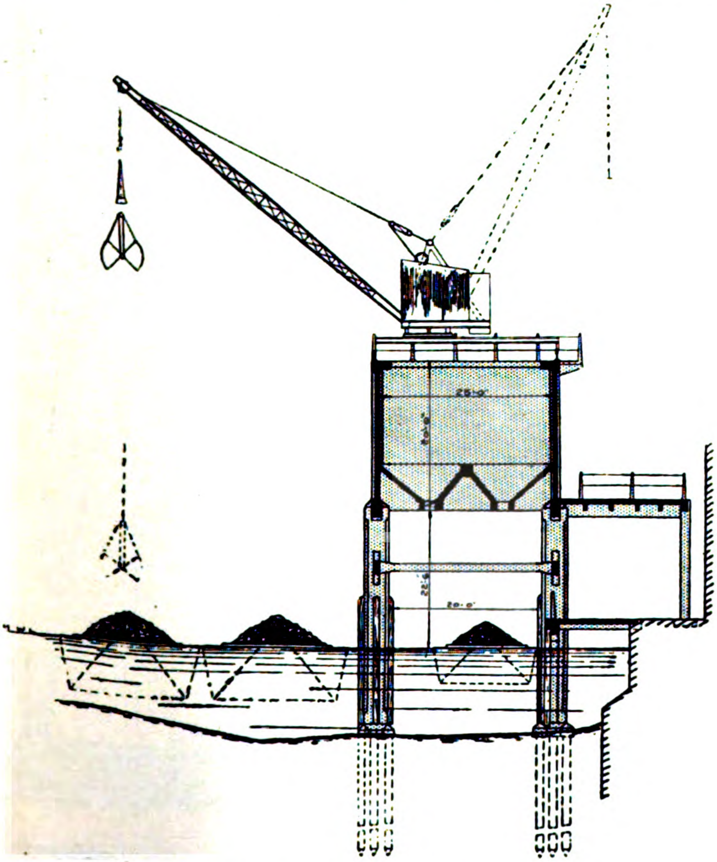


Fig. 2.—Cross-Section.

after the raising. For that purpose bars had been left projecting out of the square ring constituting the trestle foundation. After the structure had been raised and the pier rebuilt higher up, the necessary connection was arranged at its toe so that the pier load was transmitted to the completed slab. After the construction of the trestles, it was deemed desirable to make sure that their bearing was good and that they would not settle when the raising of the bunkers started. Consequently, each trestle was tested in turn by working each of its jacks to full capacity and maintaining the pressure for 48 hours. All the jacks and packing pieces having been set in position and the total weight of the bunkers resting upon the trestles, the concrete of the 8 piers was chipped off and the reinforcing rods were cut by acetylene jet to allow the structure to be raised.

In order to facilitate the work, the strong short girders upon the two ends of which the jacks were acting were suspended from the bunkers, so as to remain in position when the pressure was taken off for the purpose of packing up the jacks. The same remark applies to the short girders on each side under which packing was provided, and which carried the structure while the jacks were being packed up. This arrangement is shown more clearly by *Fig.* 6. It was necessary

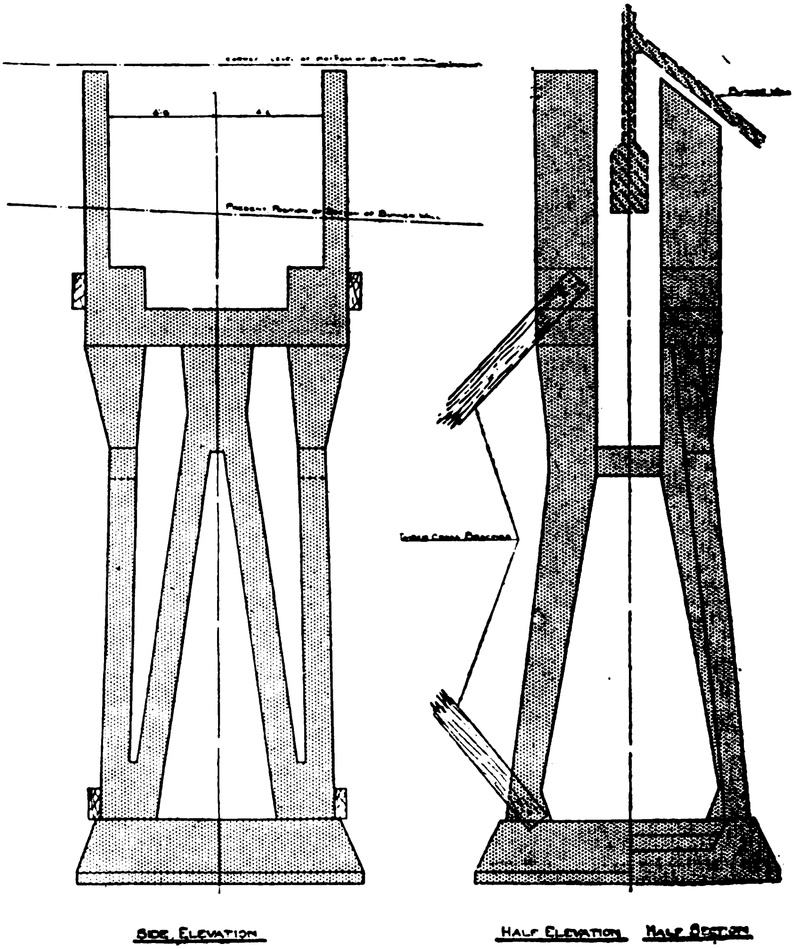
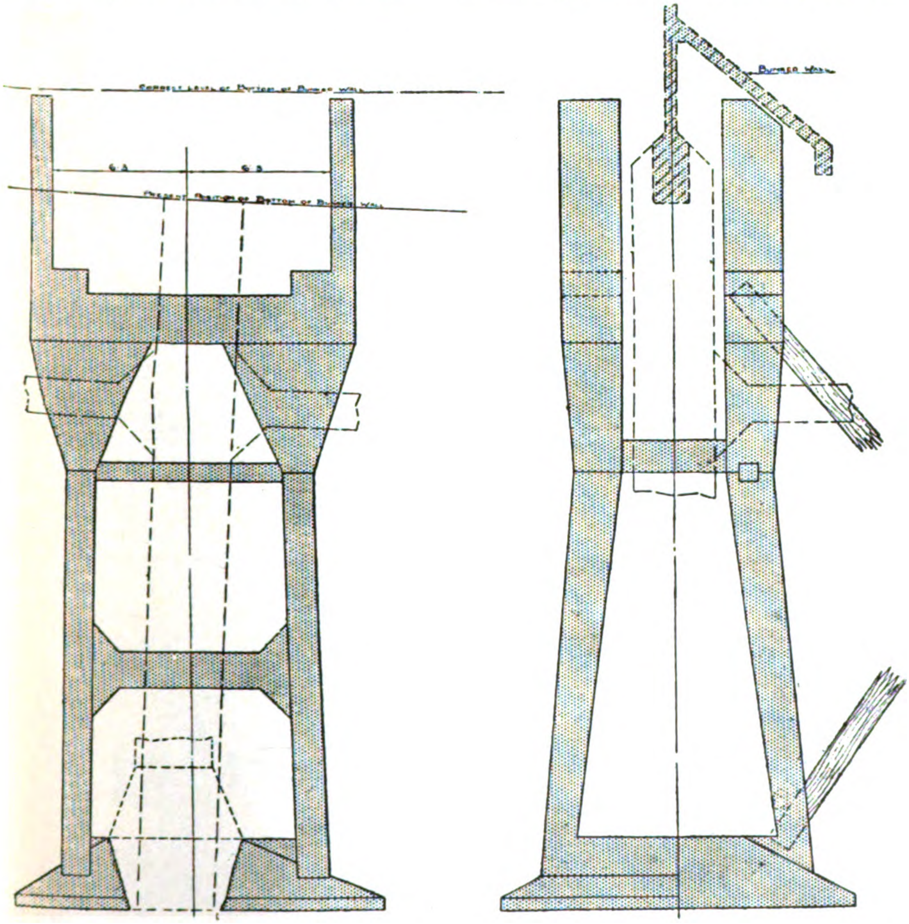


Fig. 3.—Stagings for Two Jacks (Type "A").

not to overlook the fact that at the same time as the bunker was lifted it would also probably travel horizontally, owing to the fact that the lifting consisted practically of a rotation about the upstream end, which had not subsided. In view of this, it is clear that had the short transverse joists bearing on the jacks and the packing been fixed in position relative to the bunker they would gradually have travelled clear of both jacks and packing. To overcome this difficulty these short transverse joists (each with distributing grillage of small joists attached) were slung from their ends by chains and shackles ending at the top in hooks capable of sliding along angles, which latter were securely bolted through the bunker wall. It was thus possible to maintain these joists always in the same position relative to the jacks and the packing.

It was necessary to have a fairly elaborate scaffolding, as, in addition to the men at work at the jacks, others were in charge of the packing on the top of the trestles, and others as an extra measure of security put packing between the cut ends of the piers as fast as they moved apart during the raising. (The ends of the cut bars at the top of the gap were in contact with the top of the lower part of the pier before the raising.) The stroke of the jacks was


Correct Level of Bottom of Bunker Wall
6·3
6·3
Present Position of Bottom of Bunker Wall
Bunker Wall

Side Elevation Half Elevation Half Section

Fig. 4.—Stagings for Four Jacks (Type "B").

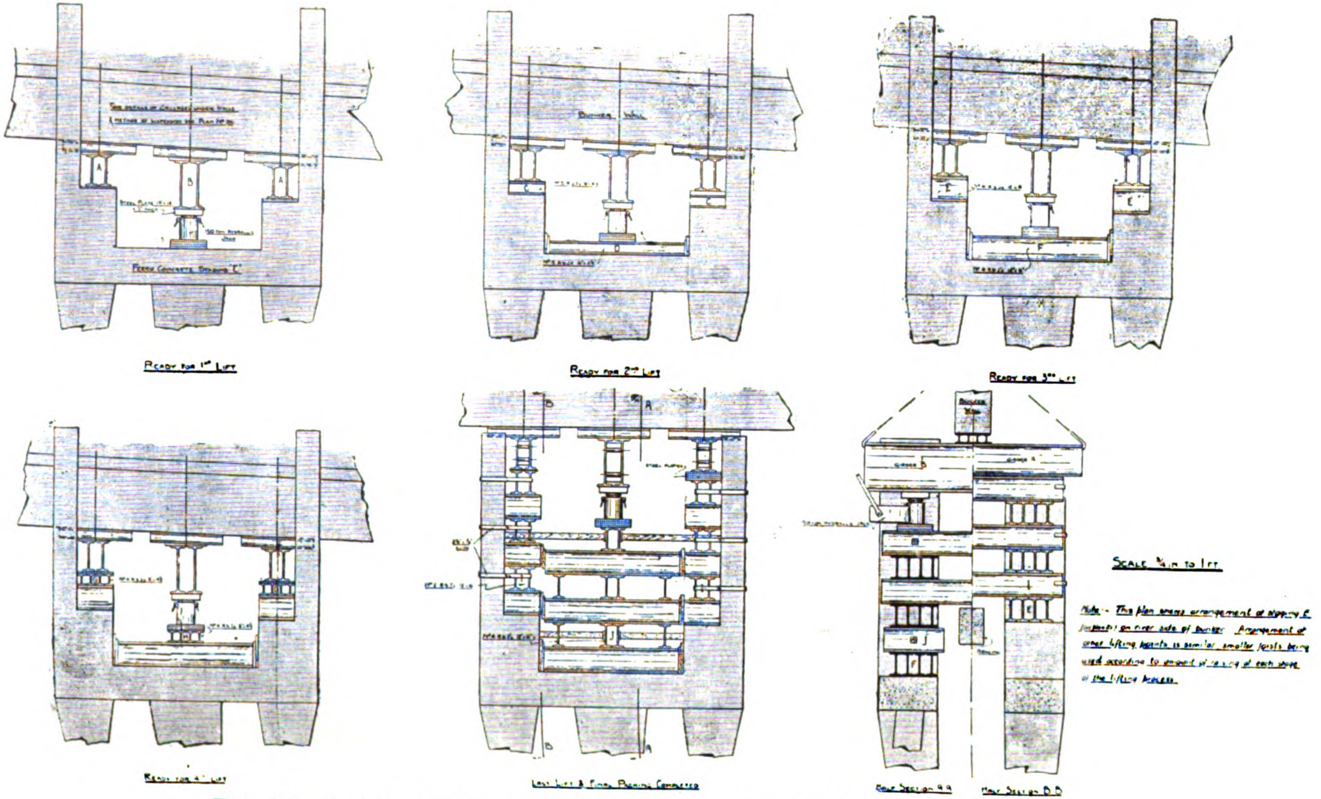

A
B
A
Fresh Concrete Section "C"
150 Ton Hydraulic Jack
Ready for 1st Lift
Bunker Wall
Ready for 2nd Lift
E
E
F
Ready for 3rd Lift
Ready for 4th Lift
B
A
J
Last Lift & Final Packing Completed
Bunker Wall
Girder B
Girder A
J
F
Half Section A.A
Half Section B.B
Scale ¼ in. to 1 ft.
Note:- This plan shows arrangement of rigging & jacks on one side of bunker. Arrangement of other lifting points is similar, smaller jacks being used according to amount of raising at each stage of the lifting process.

Fig. 5.—Arrangement of Jacks and Packing during Lifting Process.

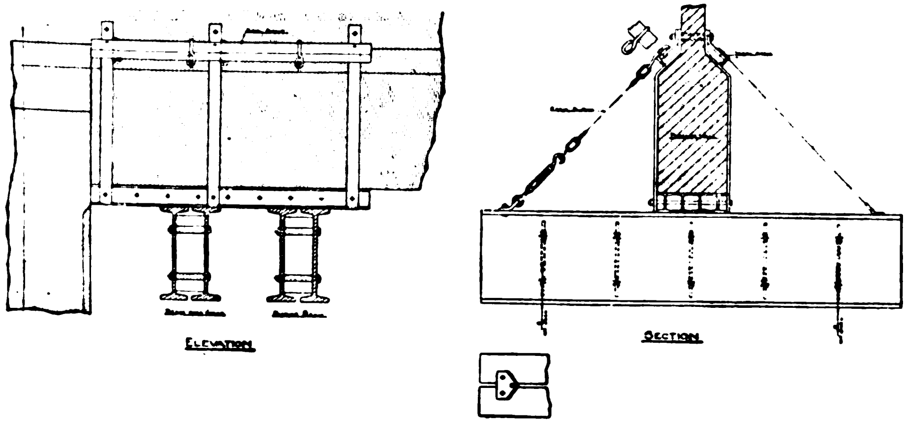


Fig. 6.—Arrangement of R.S.J.'s over Stagings.

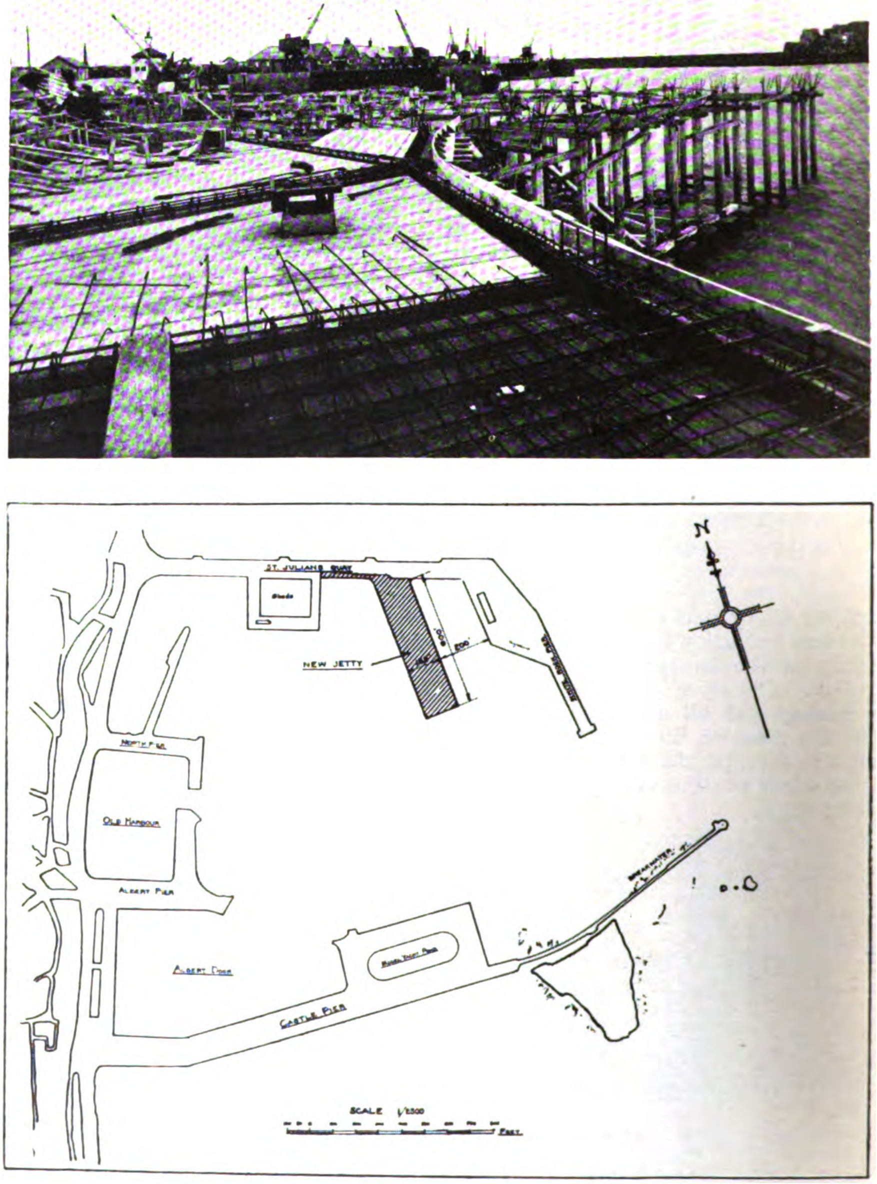
6 in., but preliminary trials had shown that it would be better to reckon upon 5 in. for each lift.

The exact load coming on each pair of jacks had been calculated, and by ensuring that the pumping was carried out for each jack so as to maintain the desired pressure and no more the raising was secured without any undue stress at any point, as might have occurred from a too rapid raising of one point. Owing to the slanting position of the bunker after settlement, the amount of lift was different for every pair of jacks.

The first operation carried out was the levelling of the bunker in a transverse direction. The work proceeded without any mishap and all according to timetable, the greatest lift in a day's work being 2 ft. 6 in. (at the downstream end), and the whole work was completed in five working days.

After the structure had been brought back to its original position, and had been carefully packed up, the reconstruction of the piers was begun. The joint between the new concrete and the old required great care, and the old concrete was thoroughly wetted by water jets squirting up from a square collar water pipe going round the pier playing against the concrete for 24 hours before concreting.

Careful records were kept while the reinstated bunker was filled up, and from time to time afterwards, not only as regards vertical movement, but also as regards any slight tilting, and it was satisfactory to note that perfect stability had been ensured. The settlements of the corner piers were from $\frac{5}{32}$ in. to $\frac{7}{32}$ in. Those of the central piers from $\frac{7}{32}$ in. to $\frac{9}{32}$ in. The bunker has now been in full work for about three years and no further movement has been observed.



Harbour Improvements at St. Peter Port. (*See p.* 277.)

Harbour Improvements at St. Peter Port, Guernsey.

SINCE the completion of the picturesque harbour of St. Peter Port in the Island of Guernsey in 1866 a large growing industry has been developed, and with it a large export trade to England, which has severely taxed the resources of the Great Western and Southern Railways owing to the somewhat limited area at their disposal.

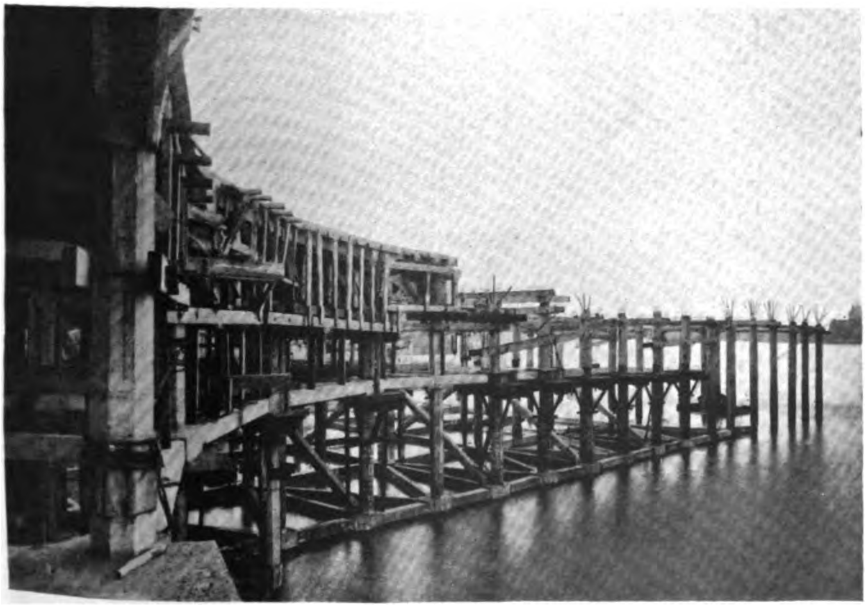
During recent years several schemes have been brought forward for increasing the quayage and area available in the Harbour for this particular industry, with a result that in 1926 work was commenced on a scheme which had received the approval of the States of Guernsey and the Privy Council.

The work now being carried out consists of the widening of an existing quay by 17 ft. for a length of about 240 ft. and the construction of a new jetty 155 ft. wide and about 650 ft. long, complete with a lower deck 20 ft. wide around three sides of the jetty. Dredging to provide deep water berths on each side of the jetty and at its southerly end is also being undertaken.

The whole of the structural work is being carried out in reinforced concrete. The superstructure is carried on piles designed by Messrs. Considère Constructions, Ltd. The 16-in. octagonal piles vary in length between 40 and 60 ft.; they are driven down to the rock by means of a piledriver mounted on a floating pontoon, and subsequently braced together with walings and bracings, which are pre-cast, and the joints made *in situ*.

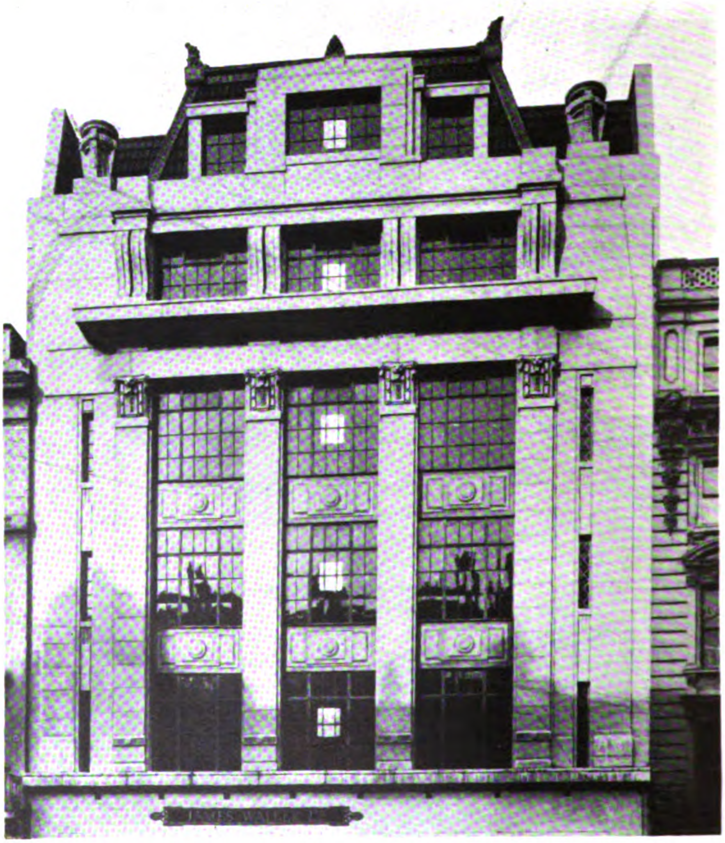
The aggregate was specified to consist of 1 part Portland cement, 1½ parts sand and 2¼ parts stone; or 0·8 parts cement if "Ferrocrete" Portland cement was used. The work is being carried out with "Ferrocrete," which enables the shuttering to be struck in 10 days as against 21 days with ordinary cement. Piles may also be handled and driven much earlier by using this cement, a great convenience to the contractors.

The upper and lower decks are surfaced with carborundum, and when the concrete has matured they are treated with silicate of soda to harden them and prevent dust being formed when under wear.



The jetty is protected by a system of fendering of greenheart timber cushioned off the piles and protected with bridge rail rubbing pieces. Provision is being made for electric travelling cranes, electric power and light services, water supply, telephone service, etc., as it is proposed to construct offices and warehouses on the jetty, which is also well supplied with bollards, mooring rings, etc.

The work is being carried out by Messrs. Sir John Jackson, Ltd., of Westminster, to designs prepared by Mr. Percy Westacott, M.Inst.C.E.



[*Cast Stone by **Empire Stone Co., Ltd.***

A Cast Stone Elevation in Oxford Street, W.

Designing Concrete for Specified Strength.

In our last number we referred to a report that has been issued by the American Concrete Institute, entitled "Economic Advantages of Field Control of Quality of Concrete," in which figures are given showing the actual savings on constructional works on which the cement-water-ratio method of designing concrete mixtures has been put into practice. An extract from this interesting report is given below:

The Committee believes that field control of concrete should be interpreted broadly to include the supervision of all the processes of concrete manufacture, that is, the supervision of:

(*a*) The quality of the constituent materials, i.e. the inspection necessary to insure a supply of cement, aggregates and water of the required quality;

(*b*) Design of the mixture, i.e. the determination of the relative proportions (or quantities) of the constituent materials to give concrete of the desired quality;

(*c*) Measurement and mixing of the constituent materials;

(*d*) Placing and curing of the concrete;

(*e*) Taking of the necessary field tests.

In this report, however, the Committee only considers the second, and more especially the importance from the economic standpoint of a careful consideration of the design of the concrete mixtures.

The problem of the design of concrete mixtures divides itself into two parts, designing for quality and designing for economy. A design to be truly successful should give both the required quality and maximum economy but, as in structural design, quality, or ability to meet the demands made upon it in service, can be obtained without reference to economy. For this reason the design of concrete for quality and for economy will be treated separately.

Investigations and experience indicate that the quality of the concrete is largely controlled by the relation between the quantity of the cement and water in the mixture, it being understood that the mixtures are workable and the constituent materials of proper quality. But a truly workable mix cannot be had without a sufficiency of fine aggregate, and, lacking this, the ordinary rules for the design of concrete cease to apply.

The underlying principle in maintaining the quality of a concrete is to keep a uniform relation between the quantity of water and cement in the mixture. For any given mix the quantity of water may be increased or decreased as required to obtain the degree of workability desired, but at the same time cement must be added or subtracted proportionately if the quality is to be uniform. Since the cement and water must be maintained in the same proportion, designing for economy demands that a combination of materials and conditions be found that will require the use of the least mixing water to obtain the desired results.

The amount of water thus necessary is governed first by the quality and character of the cement and aggregates, second by the proportions in which the materials are combined, and third by the workability required. To this should be added another factor. That is the margin of safety that the engineer must allow in setting his mixture to provide for adverse job conditions such as variable materials, poor methods of measurement, poor workmanship, etc.

Workability and Economy.

Much has been said on the advisability of using the driest possible consistency that can be handled and placed properly. Assuming a concrete designed to have a compressive strength of 2,000 lb. per sq. in. at 28 days, using sand graded from 0 to a No. 4 sieve and gravel from a No. 4 sieve to 1½ in., the cement required per cubic yard of finished concrete, as given by Abrams and Walker, is:

Slump In.	Cement Cu. ft.	Aggregate—Cu. yds.	
		Sand	Gravel
½ to 1 . . .	4·40	0·42	0·71
3 to 4 . . .	4·85	0·42	0·69
6 to 7 . . .	6·00	0·36	0·72
8 to 10 . .	7·45	0·28	0·67

The relative cost of these concretes would be as follows:

Slump In.	Cost of Material Per Cent.
½ to 1	100
3 to 4	105
6 to 7	120
8 to 10	138

Those who have experimented in practice have found that it is possible to place, satisfactorily and economically, concretes of a consistency drier than ordinarily considered possible and that a mixture with a slump exceeding 3 to 4 in. is seldom required. If, by a little forethought and planning, mixtures of a 3 to 4-in. slump can be substituted for those of a 6 to 7-in. slump, the economy resulting warrants the attention required to achieve this result.

Proportions and Economy.

In studying the effect of proportions on economy, the Committee takes a mixture designed on the basis of a concrete having a compressive strength at 28 days of 2,000 lb. per sq. in. where the common practice is followed in assuming this to be a 1 : 2 : 4 concrete. The cost of this 1 : 2 : 4 concrete is compared with a concrete designed for the required strength. In order to make the results general, the cost of mixtures is worked out as made from three differently graded sands combined with two differently graded gravels, each with each, making six different combinations. The quantities of materials required and their cost for both 1 : 2 : 4 and 2,000-lb. concrete are given in Table I, based on American costs. It should also be remembered that the 1 : 2 : 4 concrete in these examples may or may not have a strength of 2,000 lb. per sq. in. at 28 days, and while in the majority of cases where care is exercised in maintaining proper consistencies the required strength would be obtained, there are many materials, which, when combined in a proportion of 1 : 2 : 4, will not give this strength.

An actual instance of such a saving has been reported to the Committee by one of its members, Mr. J. G. Ahlers. In the case in question (a 7-story reinforced-concrete warehouse) preliminary tests showed a 1 : 2 : 4 gravel concrete would cost 25/10 per cu. yd., but using a concrete designed to have a compressive strength of 2,000 lb. per sq. in. at 28 days, the actual cost per cubic yard averaged 23/5 or a saving of 2/5 per cubic yard. As there were 1,494 cu. yds. in the job, the total saving effected was £180.

These examples serve to show the difference in cost that may exist between a concrete designed scientifically and one proportioned arbitrarily. The difference may be even more marked if such factors as placing and finishing costs could be included with these figures.

TABLE I—ARBITRARY VS. DESIGNED MIXTURES.

COMPARISON OF COST OF MATERIAL REQUIRED FOR ONE CU. YD. OF CONCRETE.

Grading of Sand Grading of Gravel	0 to ⅜ in. No. 4 to 1½ in.		0 to ⅜ in. ¾ to 1½ in.		0 to No. 4 No. 4 to 1½ in.		0 to No. 4 ¾ to 1½ in.		0 to No. 8 No. 4 to 1½ in.		0 to No. 8 ¾ to 1½ in.	
Concrete designed for	1:2:4	2000 lb.	1:2:4	2000 lb.	1:2:4	2000 lb.	1:2:4	2000 lb.	1:2:4	2000 lb.	1:2:4	2000 lb.
Cement, lbs.	445	440	445	422	445	425	448	422	448	425	450	413
Sand, cu. yd.	9·38	0·44	0·38	0·58	0·38	0·36	0·38	0·52	0·38	0·36	0·39	0·48
Gravel, cu. yd.	0·75	0·67	0·75	0·52	0·75	0·78	0·77	0·65	0·77	0·81	0·78	0·67
Cost of materials per cu. yd.	20/5	19/5	20/5	18/5	20/6	19/7	20/10	19/1	20/10	19/8	21/2½	18/9
Additional cost of 1:2:4	1/0	—	2/0	—	11*d.*	—	1/9	—	1/2	—	2/5½	—

Conditions and Economy

Abrams recommends two water-cement ratio curves, one for the average job, and the other for the job that is closely supervised. Mixtures designed for the first condition required roughly ½ cu. ft. of cement more for the same classes of concrete than those designed for the second. This is, in effect, the inclusion of a factor of safety of ½ cu. ft. of cement per cu. yd. to provide for a lack of care in handling and measuring materials, workmanship, etc.

But there are other penalties paid by the organisations that permit haphazard methods and lax supervision of their concrete. Inexact measurements often result in an overrun of 10 to 15 per cent. in the cement used. With a chuting plant they result in occasional dry batches causing plugs in the chutes and expensive interruptions in placing. Lack of care in placing and poorly designed mixes increase finishing costs. Losses from these sources (losses that are largely preventable by the application of job control) can be of considerable magnitude.

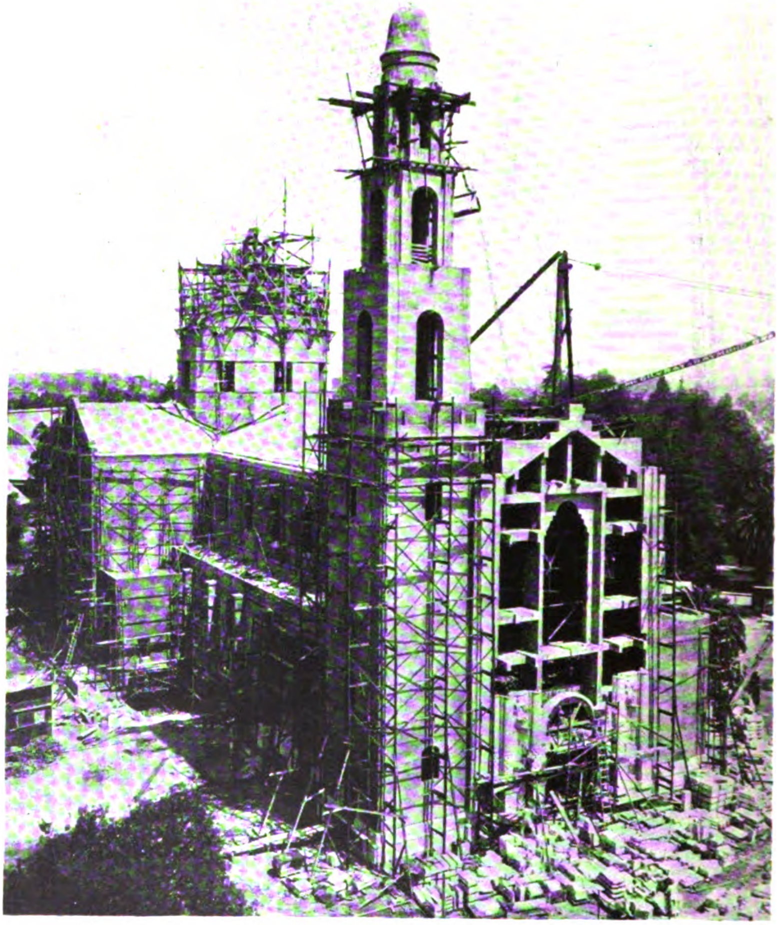
Many hold the opinion that the niceties of field control are only for the monumental concreting operations. The Committee does not agree with this view; field control can be applied to much smaller jobs with profit. Take the case of a small project with a few hundred cubic yards of concrete using a portable mixing plant of the simplest type: Assume that with this plant it would require an outlay of £20 to provide means whereby a concrete of 6 to 7-in. slump could be substituted for an 8 to 10-in. slump and that it would cost 2½*d*. more per cu. yd. to place this drier concrete. Under the conditions assumed in the previous discussion, there is a difference of 3/4 per cu. yd. in the cost of the two concretes after allowing for the additional cost of placing, and this would pay for the initial expenditure of £20 in 125 cu. yds.

Take another case. Suppose the testing required to design properly a concrete mixture by the fineness modulus method costs £5. Under the conditions of Table I, this would be recovered in from 40 to 100 cu. yds. of concrete.

Again consider the case where there is a difference in the concrete-making properties of the aggregates, when preliminary testing is required to establish the exact water-cement ratio curve. Such tests should not cost over £60 and this would be recovered on a job of 800 cu. yds. These examples are merely cited to show that methods of field control are not necessarily for the big job alone; the small job can benefit thereby.

By Emerson & Norris, Ltd.

A Cast Concrete Head.



Reinforced Concrete Church at Los Angeles.
(*See p.* 283.)

A Reinforced Concrete Church.

THE church illustrated on page 282 has just been completed at Los Angeles, California. It is built entirely of reinforced concrete, with a cement stucco face. The tower is 150 ft. in height, and the dimensions of the building are 251 ft. by 110 ft.

The foundations were designed for a soil bearing value of 3 tons per sq. ft., with all footings at least 7 ft. below the natural surface. They are in general of square or rectangular shape except those under the tower. This is supported on four wide reinforced concrete beams in order to distribute the load properly with reference to its centre of gravity. The footings supporting the nave and side aisles are tied together to ensure equal settlement.

The nave roof, which is 63 ft. 7½ in. above the main floor at the centre is supported on six reinforced concrete frames spaced 17 ft. on centres. These were designed as stiff frames. The moments occurring at the intersection of the aisle roof and nave columns were distributed into the lower nave columns, aisle girders, and aisle columns in proportion to their respective lengths and moments of inertia. The arches between the nave and aisles carry only the roof of the side aisle and the load of light filler walls. There are wide shallow beams above and below the clerestory windows to carry interior and exterior filler walls, thus providing the deep embrasures and splayed window openings required by the design.

The roofs of the nave and side aisles are concrete slabs carried on reinforced concrete purlins, which are left exposed and plastered and decorated.

The nave columns are rectangular, with a concrete section 3 ft. 4 in. wide by 2 ft. 6 in. deep. The aisle columns have an extreme depth of 6 ft. 3 in., of which 30 in. forms the architectural buttress, 8 in. is occupied by the reinforced concrete exterior wall, and the other 37 in. forms the recesses for the confessionals. The main entrance into the narthex is through a massive arched opening. This effect is obtained by using wide rectangular columns supporting beams on each face, which carry the inner and outer filler walls. The entire stone façade on each side of the opening is carried on a heavy cantilever slab at the main floor level.

The tower measures approximately 20 ft. square at the base and maintains this section for 72 ft. 7 in. Above this point it rises in four decreasing stages to a total height of 150 ft. Of the four corner columns carrying the first stage, the outer one is unsupported for a length of nearly 40 ft. except for ties of heavy reinforcing bars that are placed in the 8-in. concrete filler wall at intervals of 10 ft. At the top of the first stage there is a square frame of four large beams which support the eight columns of the smaller second stage, which is also square in section. The third and fourth stages are octagonal in shape and the eight columns of each are carried on diagonal beams supported on the columns of the lower stage. The last stage is a concrete cupola which is octagonal on the inside but has a circular surface with outside diameter of 10 ft. at the base. It is constructed of expanded metal covered with Portland cement, with a minimum thickness of 3 in.

The crossing formed by the intersection of the nave and sanctuary with the transepts is approximately 43 ft. square; four large cross-shaped columns at the corners support reinforced concrete arches, hinged at the crown. Short concrete posts from these arches carry beams arranged in the form of an octagon. Above this frame are smaller rectangular columns with a continuous wide ledge at the top at an elevation of 84 ft. 2½ in. above the nave floor. On this ledge is carried the hemispherical concrete dome 43 ft. in diameter surmounted by an octagonal concrete lantern 11 ft. 4 in. in diameter and 19 ft. 7 in. high.

The dome is designed for a wind load of 30 lbs. Dead-load includes the weight of plaster and furring on the inside, glazed tile on the outside, and a heavy concentration for the lantern and its carved stone facing.

The dome is 3⅞ in. thick at the base and 3 in. at the edge of the lantern ring. In order to distribute the load of the lantern over a larger circumferential area of the dome, eight shallow concrete ribs were introduced on the underside of the shell, starting at the edge of the ring and extending out about 8 ft. to a point where they intersect the curved surface. Solid forms were built and covered with building paper and all reinforcement was placed and wired securely. Concrete was then applied with the cement gun with a resultant hard and regular surface. Considerable care was used in the curing of this thin shell, which was covered and kept constantly moist for ten days.

The problem of acoustics in a building of this shape and size also required consideration. Solid concrete surfaces might cause excessive reverberation, and the plan of the building is such that annoying echoes were to be expected unless precautions were taken to prevent them. For this reason it was decided to line all large surfaces with some material that would absorb sound instead of reflecting it. The ceiling panels of the nave and transepts and the interior of the dome are therefore covered with acoustic felt, protected by a dust cloth and covered with perforated canvas, the purpose of the perforations being to allow the passage of sound waves to the felt where they will be absorbed and still permit the carrying out of the scheme of decoration. All walls are covered with artificial travertine, which is a highly porous material, with a view to preventing echoes and reverberation.

The concrete hoist and mixer were placed on the south side of the building in the corner formed by the intersection of nave and transept.

The shoring to support the heavy masses of concrete involved careful work in its design and erection. The arched beams over the nave had to be supported from the nave floor slab, which was poured on filled ground. To distribute this load, long 12 in. by 12 in. timbers were laid on the nave floor and the shoring erected thereon. There are no appreciable bulges, and all edges and planes are plumb and true. All concrete, except for slabs on fill, was mixed in the proportion of 1 : 2½ : 3½.

The architect, who also designed the reinforced concrete, is Mr. Albert C. Martin, of Los Angeles.

Roof to Concrete Factory in India.

[This large roof of the reinforced concrete fuse factory at Kirkee was referred to in our last number. It is covered with Callender's "Veribest" roofing felt.

Book Reviews.

"Der Grundbau." By Dr. L. Brennecke and Erich Lohmeyer. 1st volume.

261 pp. 244 illustrations, 4th edition. Paper, 19.20 mk. Cloth, 21.00 mk. (Berlin: Wilhelm Ernst & Sohn.)

A VERY excellent book on foundations and allied work, this volume covers the whole field from a general point of view, whereas the second volume will be devoted to details of the various methods of foundation. The material in the book under review is divided into four parts, of which the first deals with the soil, its properties, its carrying capacity, and the necessary examination and tests; the second gives a description of the various building materials in use for foundation work; the third part is the most interesting and gives a great deal of practical information on piles of all descriptions; the last part deals with the formation of the foundation pit generally, with its attendant contingencies of cofferdams and pumping.

Under the description of the various methods of examining and testing the ground it is interesting to note, in the chapter described as "Geophysical Investigations," the author's explanation of the efficacy of the divining rod. Another chapter gives a detailed and interesting description of the different apparatus now on the market for testing the carrying capacity of the soil. The plant required for and the execution of borings is also described at length. In the second part, dealing with the materials generally employed in foundation work, the subject is treated very fully and the reader will find the chapter on trass very useful.

Without detracting from the remainder of the book it is, however, in the part on piles and pile-driving that the most valuable and practical information is contained, the methods described being for the most part new and very up-to-date. Thus the reader finds the old pile-driving formulæ discredited (and not altogether without reason, as most engineers with experience of these formulæ will admit), and one of the newer methods of calculating the carrying capacity of the pile is introduced and exemplified. Numerous illustrations and examples are given of the many different forms of piling, both in timber, steel, concrete and reinforced concrete of the pre-cast and *in situ* type, hollow piles, and piles of special section for sheet walls.

In the chapter on timber piles it is interesting to note the reason for driving piles with the root end downwards, as is sometimes done on the Continent, where timber piles are nearly always used in the round. The last part deals with excavation and shoring; the various forms of cofferdams, both single and double, illustrated by numerous details from actual important contracts; the calculation of cofferdams and sheet piling; pumping and lowering the water level in the soil, such as may be necessary for the execution of locks, docks and tunnels; the formation of wells and the pumping plant for these purposes; with a chapter giving very detailed information as to the calculations necessary for this.

Not only is the book interesting and very useful but the clear and neatly executed illustrations add to the pleasure of perusing it.—R. N. S.

"Masonry Structures." By Frederick P. Spalding.

Second Edition. Revised by A. Lincoln Hyde and E. F. Robinson. 586 pp.; 193 illustrations.
New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Price 25s.

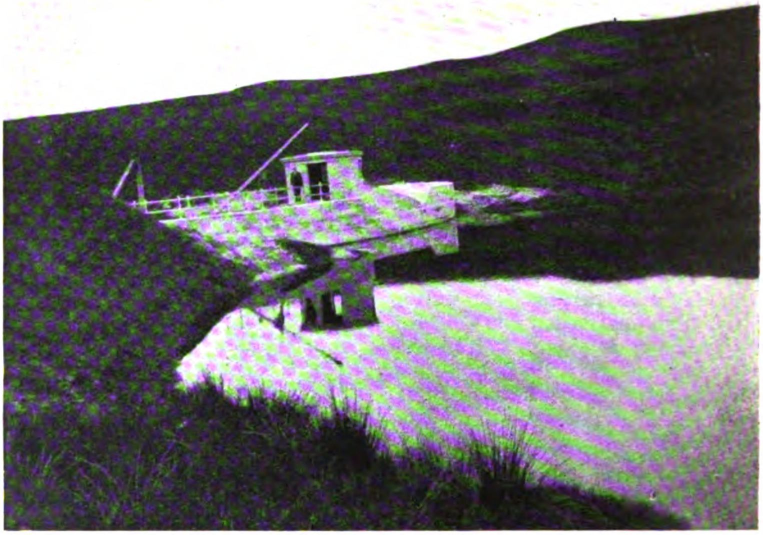
THIS volume gives a general view of the fundamental principles of the design and construction of all types of masonry structures, without attempting to cover fully the details of all classes of such structures.

The chapters deal with Cementing Materials, in which all classes of cement and mortars are discussed; Stone Masonry; Bricks and Blocks, including terra-cotta and concrete blocks; Plain Concrete; Reinforced Concrete; Retaining Walls; Dams; Bridges; Arches; Culverts and Conduits; Foundations; Piers and Abutments.

"Der Eisenbetonbau." By C. Kersten.'

(1st Volume: Elementary. 366 pp., 308 illus., 34 tables and 27 examples.) Berlin: Wilhelm Ernst & Sohn. Price 8.10 Mk.

THIS little book, in its 13th edition, by the well-known author of "Bridges in Reinforced Concrete," is a most valuable compendium for the practical concrete engineer. The author attacks the problem of imparting the maximum



Reinforced Concrete Dam at Dalmellington. (*See p.* 287.)

amount of useful knowledge in the minimum time at the disposal of the student in a most workmanlike manner, and at the outset makes up his mind to dispense with the finesses of higher theoretical meditations. At the same time the book contains all the theory that is necessary for the designer. The reader notices a minor practical departure from the usual textbook letterpress, quite insignificant in itself perhaps, but making for quick assimilation and memorising of the various formulæ—the framing and printing in heavy type of all the useful expressions and equations, thus

$$\boxed{\mathbf{h' = t + \sqrt{t^2 - wd^2}}} \quad . \quad \mathbf{(40)}$$

A small thing, but useful.

The first four chapters of the book are devoted to the purely practical side of the concrete engineer's work, and contain a mass of useful information, some of it not less valuable for showing how not to do things. The essentials and general properties of reinforced concrete, the choice of raw materials, the mixing and placing of the concrete, the steel and the formwork, all are treated with ability. The latter part of the volume deals with designing problems and presents the information in a very clear and concise form; at the end of the book is an extract of the new German regulations for reinforced concrete, which to English readers are only of interest inasmuch as they show the difference from ours by taking into consideration the improved quality of the modern cement, both as regards the allowable concrete stresses (which are increased up to 1,000 lbs. per square inch) and also the time required before striking the centering; further the steel percentage in columns and struts is made a function of the slimness of the column, with a minimum of 0·5 per cent. as against our 1 per cent.

Altogether an admirably short and perspicuous presentation of the subject, assisted in no small measure by the many excellent and well-arranged illustrations. —R. N. S.

"Reinforced Concrete Poles." By P. Gillespie and F. E. Wilson.

24 pp. 1926. University of Toronto Press.

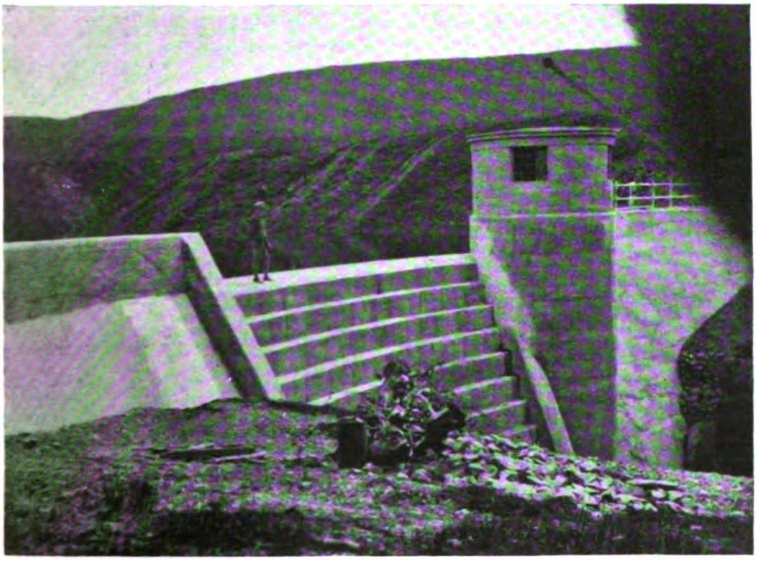
THIS pamphlet gives eight diagrams from which it is possible to estimate the stresses or obtain the safe bending moment in eight different sections of pole comprising square, circular and octagonal, solid and hollow sections. The deflection of tapered poles is investigated, also the permissible pressure of the side of poles against earth, for which a chart is given to assist in the determination of their required underground width.—L. T.

Concrete Dam at Dalmellington.

THE dam illustrated has just been completed in connection with the Dalmellington water supply. The barrier across the valley measures 187 ft. by 40 ft. deep from the bed of the stream. The inner face of the dam is coated with fine concrete, while the main body consists of ordinary concrete, the aggregate being whin metal from the bed of the stream. The spillway is formed of pre-cast concrete blocks, 2 ft. high. The valve tower up to the floor level was cast *in situ* with the main part of the dam; from the floor level to the concrete roof it is of pre-cast concrete blocks.

The top water level is 888 ft. above ordnance datum, and the storage capacity is 9,500,000 gallons. The filters, situated about half-a-mile down stream from the dam, are divided into two sets. The water from the intake pipe of the dam falls into a basin, passing through two fine-mesh sieves which can be removed separately for cleaning purposes, and then divides and falls into basins on each side and again meets at the far end in another small basin, let into which is the supply pipe to the village and an overflow pipe for any surplus that the village is unable to take.

The works were designed and supervised by Mr. J. B. Brodie, of Glasgow, and the contractor was Mr. Hugh Hastie, of Mauchline.



Reinforced Concrete Dam at Dalmellington.

Scientific and Industrial Research.

MR. HENRY THOMAS TIZARD, C.B., A.F.C., F.R.S., has been appointed Secretary to the Committee of the Privy Council for Scientific and Industrial Research on the retirement of Sir H. Frank Heath, K.C.B., from that office on June 1 next.

DATA FOR PRICING REINFORCED CONCRETE.*

MATERIALS DELIVERED 4 MILES FROM CHARING CROSS.

		s.	d.
Best Washed Sand	per yard	16	0
Clean Shingle, ¾ in. mesh	,,	14	0
,, ,, ½ in. mesh	,,	15	6
Thames ballast	,,	10	6
Broken brick (¾ in.)	,,	11	6
Best British Portland Cement (delivered London area).	per ton 58*s.* to	63	6
"Ferrocrete" Rapid-Hardening Portland Cement	delivered London 10*s.* per ton extra		
"Super-Cement"	per ton 88*s.* to	93	0
"Lightning" Brand Aluminous Cement	,, 100*s.* to	105	6
Ciment Fondu	works f.o.r.	95	0

Boarding for Shuttering—

		Sawn. s.	*Sawn.* d.	*Wrot.* s.	*Wrot.* d.
1 in.	per square	23	6	27	6
1¼ in.	,,	29	6	33	6
1½ in.	,,	35	6	41	0

Sawn Timber for Struts and Supports—

3 in. by 4 in.	from £22 per standard
3 in. by 6 in. and 3 in. by 7 in.	,, £20 ,, ,,

Mild Steel Rods for Reinforcement—

		s.	d.
⅝ in. to 2⅞ in. Rounds	per cwt.	10	6
7/16 in. to ½ in. Rounds	,,	10	9
⅜ in. Rounds	,,	11	0
¼ in. Rounds	,,	12	0

Breeze Slabs per yd. super: 2 in., 1/11; 2½ in., 2/4; 3 in., 2/9; 4 in., 3/6.

MATERIAL AND LABOUR, INCLUDING 10 PER CENT. PROFIT.

(Based on Contracts up to £2,000.)

Portland Cement Concrete well mixed in proportion 1 : 2 : 4—

				s.	d.
Do.	do.	in foundation	per foot cube	1	11
Do.	do.	in columns	,, ,,	2	1
Do.	do.	in beams	,, ,,	2	3
Do.	do.	in floor slabs 4 in. thick	per yard super	6	0
Do.	do.	in floor slabs 5 in. thick	,, ,,	7	6
Do.	do.	in floor slabs 6 in. thick	,, ,,	9	0
Do.	do.	in floor slabs 7 in. thick	,, ,,	10	6
Do.	do.	in walls 6 in. thick	,, ,,	8	8

(Add for hoisting 3s. 6d. per yard cube above ground-floor level. Add for "Ferrocrete" 1s. 10d. per yard cube.)

Steel Reinforcement, including Cutting, Bending and putting into Position and securing with Stout Binding Wire—

		s.	d.
From ¼ in. to ⅜ in.	per cwt.	22	6
,, 7/16 in. to ½ in.	,,	21	6
,, ⅝ in. to 2⅞ in.	,,	20	6

EXTRA LABOUR TO BENDS in ¼-in. rods, ½*d.*; ⅜-in. rods, 1*d.*; ½-in. rods, 1¼*d.*; ⅝-in. rods, 1½*d.*; ¾-in. rods, 1¾*d.*; ⅞-in. rods, 2*d.*; 1-in. rods, 2¼*d.*; 1⅛-in. rods, 3*d.*; 1¼-in. rods, 3½*d.*; 1⅜-in. rods, 4½*d.*; 1½-in. rods. 6*d.* (per bend per cwt.).

EXTRA LABOUR TO HOOK BENDS: ¼ in., 1*d.*; ⅜ in., 2*d.*; ½ in., 2½*d.*; ⅝ in., 3*d.*; ¾ in., 3½*d.*; ⅞ in., 4*d.*; 1 in., 4½*d.*; 1⅛ in., 6*d.*; 1¼ in., 7*d.* (per bend per cwt.).

Shuttering—

		s.	d.
Shuttering and Supports for Concrete Walls (both sides measured)	per square	59	0
Centering to Soffits of Reinforced Concrete Floors and Strutting, average 10 ft. high	per square	55	0
Do. do. in small quantities	per ft. super	0	10
Shuttering and Supports to Stanchions for easy removal, average 18 in. by 18 in.	per ft. super	0	11½
Do. do. as last, in narrow widths	,, ,,	1	1½
Do. do. to sides and soffits of beams, average 9 in. by 12 in.	,, ,,	1	1½
Do. do. as last, in narrow widths	,, ,,	1	3½
Raking, cutting, and waste to shuttering	per ft. run	0	3
Labour, splay on ditto	,, ,,	0	2
Small angle fillets fixed to internal angles of shuttering to form chamfer	,, ,,	0	3

WAGES.—The rates of wages on which the above prices are based are:—Carpenters and joiners, 1/9½ per hour; Carpenters working on old shuttering, 1/10½; Labourers on building works, 1/4½; Men on mixers and hoists, 1/5½; Bar-benders, 1/5½.

[* This Data is specially compiled for *Concrete and Constructional Engineering*, and is strictly copyright.]

Prospective New Concrete Work.

ARMAGH.—*Houses.*—The R.D.C. proposes to spend £21,607 on the construction of 66 houses.

BARNSLEY.—*Houses.*—The T.C. proposes to erect 200 houses by direct labour.

BARTON.—*Bridge.*—A scheme for the provision of a bridge over the Manchester Ship Canal at Barton is being considered by the local authorities and the Manchester Ship Canal and Trafford Park Estates Co., Ltd.

BELFAST.—*Houses.*—The Corporation proposes to spend £27,000 on the construc- of 100 houses at Seaview.

BERKHAMSTED.—*Houses.*—The U.D.C. has made application for permission to borrow £25,802 for the construction of 55 houses on the Swing Gate Lane estate.

BLACKWATER.—*Concrete Bridge.*—The Berks. and Surrey C.C.'s have submitted plans for the construction of a reinforced concrete bridge to the Southern Railway Co.

CARMARTHEN.—*Houses.*—The T.C. proposes to build 26 houses at the Morgam Arms Field.

COLERAINE. — *Concrete Roads.* — The U.D.C. proposes to spend £9,000 on the construction of concrete roads.

DEAL.—*Houses.*—The T.C. is considering a scheme for the erection of 48 houses on a site near Mill Hill.

DURHAM.—*Houses.*—The Corporation has decided to build 114 houses at Sunderland Road.

EASTBOURNE.—*Sea Wall.*—The T.C. has applied for sanction to borrow £1,200 for extending the sea wall at Holywell.

FAILSWORTH.—*Houses.*—The U.D.C. has applied for sanction to borrow £20,260 for the construction of 40 houses on the Lore Lane estate.

FLEETWOOD. — *Houses.* — Application has been made for sanction to borrow £12,140 for the erection of 24 houses.

FOLKESTONE.—*Houses.*—The T.C. has decided to erect 162 houses on a site between Canterbury Road and Dover Road.

FRIMLEY.—*Houses.*—The U.D.C. proposes to erect 50 houses.

FROME.—*Houses.*—The U.D.C. proposes to build 50 houses on the Keyford site.

HORBURY.—*Houses.*—The U.D.C. has applied for sanction to borrow £11,032 for the erection of 28 houses at Hanworth Road.

JOHNSTONE.—*Houses.*—The T.C. has applied for permission to borrow £100,000 for the erection of houses.

KEYNSHAM.—*Houses.*—The Surveyor has been instructed to prepare plans for the erection of 24 houses.

KIRKCALDY.—*Houses.*—The District Committee is considering a scheme for the construction of 396 houses.

LICHFIELD. — *Concrete Bridge.* — The Staffs. C.C. proposes to construct a reinforced concrete bridge to replace the existing Bell Canal Bridge.

LLANDUDNO.—*Houses.*—The U.D.C. has decided to build 30 houses at Maesdu.

LONDON. — *Houses.* — The Housing Committee has recommended the L.C.C. to erect 1,020 houses on the Watling Estate near Edgware Road. The cost is estimated at £600,000.

LOUTH.—*Houses.*—The T.C. proposes to build 57 houses on the Newmarket site.

LUDWORTH.—*Houses.*—The Durham R.D.C. is considering a proposal to build 50 houses at Ludworth.

MAIDENHEAD.—*Houses.*—The T.C. is considering a scheme for the erection of 55 houses on a site at Cox Green Road.

NAPTON. — *Concrete Tank.* — The Southam R.D.C. proposes to spend £150 on the construction of a reinforced concrete tank to hold 1,000 gallons.

NEWCASTLE-UNDER-LYME. — *Houses.*— The T.C. is preparing a scheme for the erection of 150 houses.

PERSHORE.—*Houses.*—The R.D.C. is considering a scheme for the construction of 100 houses.

PONTYPOOL.—*Road.*—The Surveyor has been instructed to prepare plans for the construction of a road from Osborne Road to Lower Crane Street.

POYNTON.—*Bridge.*—The Macclesfield R.D.C. is considering a scheme for the construction of a bridge at Mill Hill, Chester Road.

RAMSGATE.—*Houses.*—The T.C. has decided to build 40 houses.

SANDWICH. — *Bridge.* — The Eastry R.D.C. has submitted plans for the construction of a bridge over the Delf at Howe Wall.

SHEFFIELD.—*Bungalows.*—The Corporation is recommended to build 50 bungalows on the Ridgeway Road estate.

PATENTS.

THE owners of British Patent No. 214962 for Improvements in Concrete Building Blocks are desirous of entering into negotiations with one or more firms in Great Britain for the purpose of exploiting the above invention, either by sale of the patent rights or by the grant of a licence or licences to manufacture on royalty. Enquiries should be addressed to Messrs. ABEL & IMRAY, 30 Southampton Buildings, London, W.C.2.

PATENTS.

THE owners of British Patent No. 212244 for Improvements in and relating to metal beams, and No. 212886 for Improvements in and relating to the rolling of metal beams and like structural elements, are desirous of entering into negotiations with one or more firms in Great Britain for the purpose of exploiting the above inventions either by the sale of the patent rights or by the grant of a licence or licences to manufacture on royalty. Enquiries should be addressed to Messrs. ABEL & IMRAY, 30 Southampton Buildings, London, W.C.2.

PATENT.

THE Proprietor of the Patent No. 222151 for Process of Manufacturing Cementitious Materials is desirous of entering into arrangements by way of licence and otherwise on reasonable terms for the purpose of exploiting the same and ensuring its full development and practical working in this country. All communications should be addressed in the first instance to HASELTINE, LAKE & CO., Chartered Patent Agents, 28 Southampton Buildings, Chancery Lane, London, W.C.2.

WATERPROOFING.

ENGINEERS in concrete and other construction interested in the introduction of sound Waterproofing Compounds who are desirous of taking up the position of Stockholders, embracing areas covering Counties of Great Britain and Ireland, for an English Company situated in London, are invited to forward applications with a view to early negotiations and arrangement for appointment. Apply Box No. 1266, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 20 Dartmouth Street, Westminster, S.W.1.

SOLIHULL.—*Houses.*—The U.D.C. has made application for permission to build 72 houses.

SOUTHPORT.—*Houses.*—The T.C. has applied for sanction to borrow £27,554 for the construction of 56 houses.

STAFFORD. — *Concrete Road.* — The R.D.C. proposes to construct the new Burton Manor Road in reinforced concrete.

STOCKPORT.—*Houses.*—The Corporation has purchased a housing site adjoining Didsbury Road.

STOCKTON. — *Road.* — The Highways Committee is considering a scheme for the construction of a road from Portrack to Tilery.

SUNDERLAND.—*Houses.*—The Corporation proposes to purchase 134 acres of the Ford Hall estate for housing purposes.

SUTTON COLDFIELD.—Houses.—Application has been made for sanction to borrow £15,000 for the construction of 36 houses.

SWINDON.—*Houses.*—The T.C. has decided to erect 100 houses on the Hurst estate.

TARLETON.—*Road.*—The Lancs. C.C. is recommended to apply for sanction to borrow £15,000 for a road diversion at Tarleton on the Southport to Preston Road.

THORPE. — *Houses.* — The Blofield R.D.C. proposes to build 50 houses.

UFFCULME. — *Bridge.* — A bridge is to be erected over the River Culm at the Hams, between Willand and Uffculme.

WALSINGHAM.—*Houses.*—The R.D.C. proposes to erect 24 houses in the district.

WHITTLESEY.—*Houses.*—The U.D.C. has been recommended to build 50 houses.

WILLINGTON. — *Houses.* — The U.D.C. has applied for permission to build 60 houses.

Tenders Accepted.

ECCLES.—*Concrete Floors.*—The T.C. has accepted the tender of the Fram Reinforced Concrete Co., Ltd., Manchester, at £597, for the construction of reinforced concrete floors at the Main Stores.

GLOUCESTER.—*Concrete Water Tank.*—The City Council has accepted the tender of Messrs. Hobrough & Co., Ltd., Gloucester, at £207, for the construction of a concrete water tank at the rear of the public baths.

MILFORD.—*Concrete Reservoir.*—The Stafford T.C. has accepted the tender of the Cumberland Reinforced Concrete Construction and Artificial Stone Co., Harrington, at £8,894, for the construction of a concrete reservoir.

DUCKHAM'S
CONCRETE
MOULD
OIL
•
GOES FARTHEST
FUNCTIONS BEST
ALEXANDER DUCKHAM & Co., Ltd.
6 BROAD ST. PLACE, LONDON, E.C.2

MOLESEY. — *Concrete Houses.* — The U.D.C. has accepted the tender of the Triangular Construction Co., Ltd., at £12,490, for the construction of 44 concrete houses.

SOUTH MIMMS.—*Concrete Culvert.*—The R.D.C. has accepted the tender of Messrs. J. W. McMillan & Co., Hatfield, at £132 10*s.* for the construction of a reinforced concrete culvert.

UTTOXETER.—*Concrete Bridge.*—The R.D.C. has accepted the tender of Mr. W. A. Porter, Melbourne, at £334 19*s.*, for the construction of a reinforced concrete bridge over the Ashbrook at Bromley Hurst. Other tenders submitted: Hobrough & Co., £747 8*s.* 2*d.*; W. Muirhead, Macdonald Wilson & Co., Ltd., £706 13*s.* 2*d.*; Sir John Payne Gallwey, Ltd., £655 13*s.* 2*d.*; Gray's Ferro-Concrete Co., Ltd., £643 8*s.* 7*d.*; C. A. Horton, £617; Anglo-Danish Concrete Construction Co., Ltd., £530; Andrew Blair, Lyell & Co., £528 13*s.*; Reinforced Concrete Construction Co., £508 1*s.* 7*d.*; H. Middleton, £481 3*s.* 2*d.*; E. E. Jeavons & Co., £412 5*s.* 2*d.*; W. P. Taylor & Co., Ltd., £412 5*s.* 2*d.*; Ward & Godbehere, £381; Bridge & Engineering Co., £360 17*s.*

WALLASEY.—*Concrete Road.*—The Corporation has accepted the tender of Mr. C. L. Warren, Wallasey, at £4,439, for reconstructing Penkett Road and Earlston Road in reinforced concrete. Other tenders submitted: J. McGeoch & Sons, £4,439; G. Law, Ltd., £5,362; W. H. Worthington, Ltd., £5,656; Tarslag (1923), Ltd., £5,666; S. & G. Graham, £5,967; F. Mitchell & Sons, Ltd., £6,124; Walker-Weston Co., Ltd., £7,563.

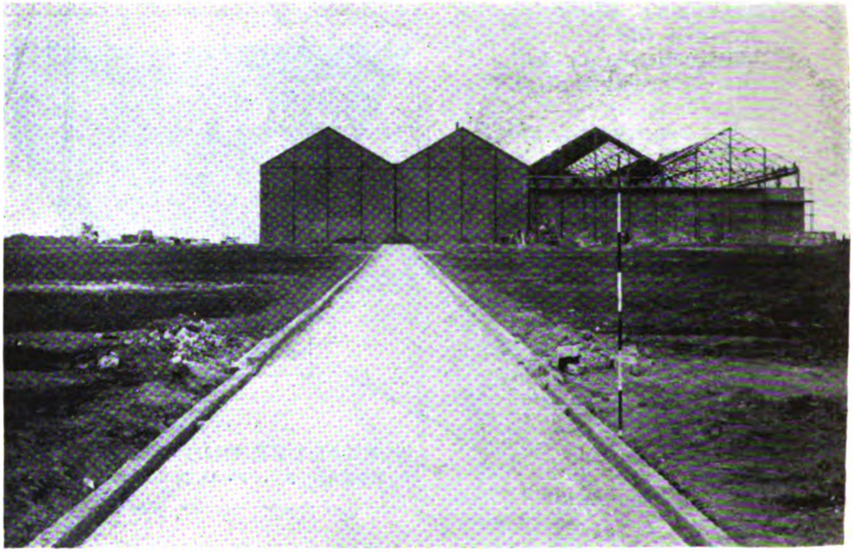
WINCHESTER. — *Houses.* — The City Council has accepted the tender of the Monolithic Building Co., at £16,548, for the construction of 42 concrete houses on the St. Giles' Hill Site.

YEOVIL.—*Concrete Road.*—The T.C. has accepted the tender of the Walker-Weston Co., Ltd., for the construction of a reinforced concrete roadway.

Trade Notices.

Manchester Building Exhibition.—Messrs. Turner Brothers Asbestos Co., Ltd., of Trafford Park, makers of the well-known "Trafford" tiles and "Permanite" asbestos-cement slates, exhibited at the recent Manchester Building Trades Exhibition three entirely new lines, which should contribute to building economy and permit of wider scope in interior decoration and roofing design. The "Serval" multiple tile is supplied in a rich russet-brown colour. It is an entirely new idea in roofing—a boldly designed and readily fixed unit, that has the effect when in position of pantiles of substantial thickness. These units, by reason of their large size, effect an economy in roof construction and erection costs. Roofing spars may safely be opened up to 3 ft. spacing, according to bearing, with 2 in. by 2 in. battens at 21½-in. centres. In addition there was on view a wide range of "Permanite" fire-resisting asbestos-cement products of different types for all roofing and wall lining purposes.

Special prominence was given to concrete mixers made by Stothert & Pitt, Ltd. These mixers are used for many other purposes as well as the mixing of concrete, although their pre-eminent service is concrete mixing. The Victoria H.M. mixer (hand or power) All-on model was shown complete with side loader and water tank,



Reinforced Concrete Works Road.

[This all-concrete road has just been completed at the new works near Shrewsbury of the Chatwood Safe Co., Ltd. The reinforcement is B. R.C. fabric.]

direct driven by a 2½ H.P. petrol engine all mounted on wheels, and so balanced that one man can wheel it. The mixed capacity is 3 cu. ft. per batch. The light "Smith" tilting drum mixer, particularly adaptable for works where space is limited, was shown. The mixed capacity is 4½ cu. ft., and it is driven by a 3½ H.P. petrol engine. Another machine shown was the No. 7 "Victoria" mixer, of 7 cu. ft. mixed capacity, with 5 H.P. petrol engine. This type is made up to 2 cu. yds. mixed capacity.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XXII. No. 5. LONDON, MAY, 1927.

EDITORIAL NOTE.

Building Research.

BUILDING research is now conducted by the Department of Scientific and Industrial Research in an extensive and well-equipped establishment at Watford, and as the expenditure on this work is at the rate of £25,000 per annum there should be every prospect of comprehensive results of value to the building industry being obtained in course of time. Scientific research is not the operation of a few men of genius who are supposed to have the faculty of making brilliant discoveries by intuition or by the workings of exceptional brains. The research work that brings results in the long run is that which consists in the exploration of likely avenues of experiment and in the opening up of new paths of exploration, always with a basis of scientific knowledge. Such work usually demands scores, or even thousands, of experiments which when collated indicate the right path of progress, lead to the elimination of useless investigations, and permit of conclusions being drawn. The basis of research is scientific common sense under the guidance of leaders of experience endowed with qualities of perseverance. On this basis time and money are practically certain to yield results.

The traditional knowledge already existing in the building industry has been acquired by expensive methods of trial and error, and there is hardly any doubt that scientific knowledge would have shown that many of the trials made were fundamentally unsound and certain to lead to failure. The objective in view of the Building Research Board as stated in the Report of the Committee of the Privy Council for Scientific and Industrial Research for the year 1925/26 is, " The creation of a real science of building which may serve to explain and supplement the traditional knowledge possessed to-day in the industry."

The development of the concrete industry on scientific lines has been consistently urged in this Journal, and the publications of the Building Research Board in these columns and elsewhere show that research work on concrete forms an important part of its activities. The Board invites the co-operation of those engaged in the building industry, and is desirous of providing data for inquirers. Emphasis is laid on the great assistance that would be rendered by the opportunity of examination by scientific men of the failures that occasionally occur in building work.

The enlarged station at Watford has been in use for little more than a year, and already twelve reports and pamphlets have been published or are in the press. It may therefore be anticipated that when the initial and inevitable spade work has been completed the operations of the Building Research Board will have a considerable influence upon the development of the building industry.

English and American Building Costs.

THE comparison of building methods and costs in this country and in the United States, by Mr. Harvey Corbett, given on p. 319 of this number, bears no particular relation to concrete construction, but the notes on American methods and the suggestions contained therein are of very general interest to all concerned with building. It is a remarkable fact that in spite of building trade wages in New York being about five times as high as in London, the cost of buildings per foot cube is practically the same in both cities. It appears that materials cost, on the average, the same in both cases. The obvious inference is that in America more work is obtained for wages paid, and it is on this point that Mr. Corbett has some interesting things to say.

Superior organisation is, in his opinion, the vital factor that enables full value to be obtained for the high wages paid. When the skilled operatives are paid up to 10s. an hour there is undoubtedly a great incentive for the contractor to avoid keeping them standing about waiting for materials, and to arrange the work so that one trade follows another without delay. Thus the programme of operations is mapped out in advance, and rigidly adhered to. Whether this is possible in this country to the same extent is doubtful, for in the United States all connected with the building appear to work in co-operation from start to finish. The architect's design once it is decided upon is followed to the completion; we should imagine it would be some time before the majority of the architects of this country issue drawings from which they do not wish to depart while the work is in course of construction. Conditions in the two countries are different in several respects, and particularly in the attitude of the architectural profession. Whether or not it is due to the fact that the commercial building in America has become more or less standardised we do not know, but Mr. Corbett tells us that those huge buildings are designed in a few weeks and the drawings strictly followed without the slightest alteration throughout the whole of the work. This, we should think, is one of the most important factors influencing costs. If there is not standardisation in American building design, there is a great deal of standardisation in details which facilitate construction and cheapen manufactured units. And on multi-story buildings there is repetition from floor to floor which must result in considerably cheapening the cost per foot cube in comparison with the lower buildings of London.

Concrete Railway Track.

CONSIDERABLE discussion seems to be taking place in the United States as to the suitability of the ballast track now generally used on railways, and attention is being given to the substitution of reinforced concrete for the permanent way.

One of the earliest attempts in this direction was made in 1909, when the rails of a section of the D. L. & W. Railroad was laid on reinforced concrete slabs designed by the chief engineer to the railway, who in 1916 stated that this track had "demonstrated fully that this type of track, if made perfectly rigid, would stand up against the heaviest type of traffic." The section was laid to test the engineer's theory that if railway tracks were made perfectly rigid and unyielding there would be no pounding or unusual stress on the rails. He had formed the opinion that ballast tracks had reached the limit of loading, and that modern loads caused excessive deflections on rails laid on ballast.

In a recent paper the President of the Pere Marquette Railway stated that many United States railways had laid rails on permanent track for short sections, such as in tunnels and at termini, and in every case they had proved successful after several years' use. On p. 303 we give some particulars of a design for a reinforced concrete track, and some figures of cost worked out by the President of the Pere Marquette Railway showing that, on American costs, the concrete track would result in a saving of nearly £800 a year per mile on a line with a traffic of 30,000 tons a day or nearly £1,000 on a line with a traffic of 40,000 tons a day. The heavier the traffic the more is the anticipated saving possible by the substitution of reinforced concrete for ballast. Economy of permanent-way maintenance is put at 20 per cent., while there would also probably be a saving in the maintenance of rolling stock. It is further claimed that the rigid rail bed would permit of higher speeds, and that the tractive effort would be less.

We understand that more than one railway in the United States is at present laying experimental sections of reinforced concrete track as a result of the experience gained on experimental sections laid as long as eighteen years ago.

It is, of course, probable that owing to the lack of resiliency of the track the springing of the trains would have to receive more attention, or shock absorbers introduced between the rail and the track, but the interest in this direction in America suggests that experimental permanent tracks might with advantage be laid in this country.

Aluminous Cement Concrete subjected to Heat.

DURING the construction of a new reinforced concrete bridge at Plougastel, France, which when completed will be the largest reinforced concrete bridge in the world, it was discovered that three or four cubic yards of concrete failed to harden. The bridge is being constructed in aluminous cement concrete, to the design of M. Freysinnet, and this small piece was the only part of the huge undertaking that did not harden properly. It was noted that the faulty patches did not possess what M. Freysinnet terms the "characteristic colour of ciment fondu," and that they were distinguished by a dark blue-green colour or by a reddish clayey-yellow; the former colour is not permanent in the presence of air, and disappears when the concrete is broken.

A series of tests was undertaken to discover the cause of the phenomenon, and after lengthy experiments and investigations it was found that the faulty concrete was due to the very hot weather experienced at the time this concrete was placed. The tests were therefore undertaken to ascertain the effect of heat on the setting of aluminous cement concrete. These tests showed that M. Freysinnet's surmise was correct, and that special precautions must be taken in placing aluminous cement in very hot weather. The heat which had a serious effect in reducing the strength of the concrete was, however, as high as 97 deg. Fahr., which, of course, is seldom experienced in this country. The point should, however, be noted by those responsible for placing aluminous cement concrete in the tropics, where the action of the sun's rays on shuttering might raise the temperature of the concrete to a dangerous degree. Some of the test pieces were gauged with warm water and some with sea water, and both resulted in reducing strength, but the cause of the faulty patches is attributed primarily to the exposure of the shuttering containing the freshly poured concrete to very great heat from the sun.

In connection with M. Freysinnet's reference to the "characteristic colour of ciment fondu," it may be pointed out that this cement is liable to considerable variations of colour caused by variations in the iron content of the bauxite; ciment fondu may vary from very dark to light grey, but this bears no relation to the quality of the cement. The colour of these faulty pieces was, however, quite foreign to the material.

We understand that an exhaustive series of tests has just been commenced at the National Physical Laboratory to determine exactly the effect of using warm gauging water with aluminous cement concrete, and also the effect of allowing such concrete to harden in various temperatures from 60 deg. Fahr. to 130 deg. Fahr. These tests are expected to take about six months to complete, when the results will be published in this journal.

Professor Duff Abrams.

THE name of Professor Duff A. Abrams has become well known in this country, where his researches on cement and concrete have received wide publicity, particularly in the development of the cement-water-ratio theory of proportioning concrete. For five years, from 1911 to 1916, Professor Abrams was Director of the Structural Materials Laboratory of the Lewis Institute at Chicago, and when that organisation was taken over by the American Portland Cement Association in 1916 he continued as Director of Research of the Association. During this period he carried out a vast amount of experimental work, much of it on an enormous scale. Professor Abrams has now resigned his position with the Association to take up private practice as a consulting engineer in reinforced concrete, finding, like many before him, that active work in the construction field has more attractions than laboratory research. Mr. F. R. MacMillan has been appointed Director of Research to the Association in place of Professor Abrams.

Concentrated Loads on Reinforced Concrete Slabs.

A Discussion on their Distribution.

By **EWART S. ANDREWS, B.Sc., A.M.Inst.C.E.**

THERE are a number of problems in reinforced concrete design which are difficult of solution because we have not sufficient experimental knowledge upon which to base scientific rules of design. In some such problems it is possible to obtain a theoretical solution by the ordinary mathematical processes, and we usually adopt such solutions if they are not in conflict with experimental fact; in other cases it is almost impossible to proceed upon mathematical rules, and the problem before us is one of these.

Many of these problems relate to points that are occurring almost every day in practical design where a decision of some kind has to be made, and it is surprising that so little is to be found in the textbooks upon this question of fundamental importance.

Fig. 1 illustrates the problem. A load W is concentrated on the small area (shown shaded) of a reinforced concrete slab spanning between beams XV and YZ. With due allowance for continuity of the slab, if any, we arrive without

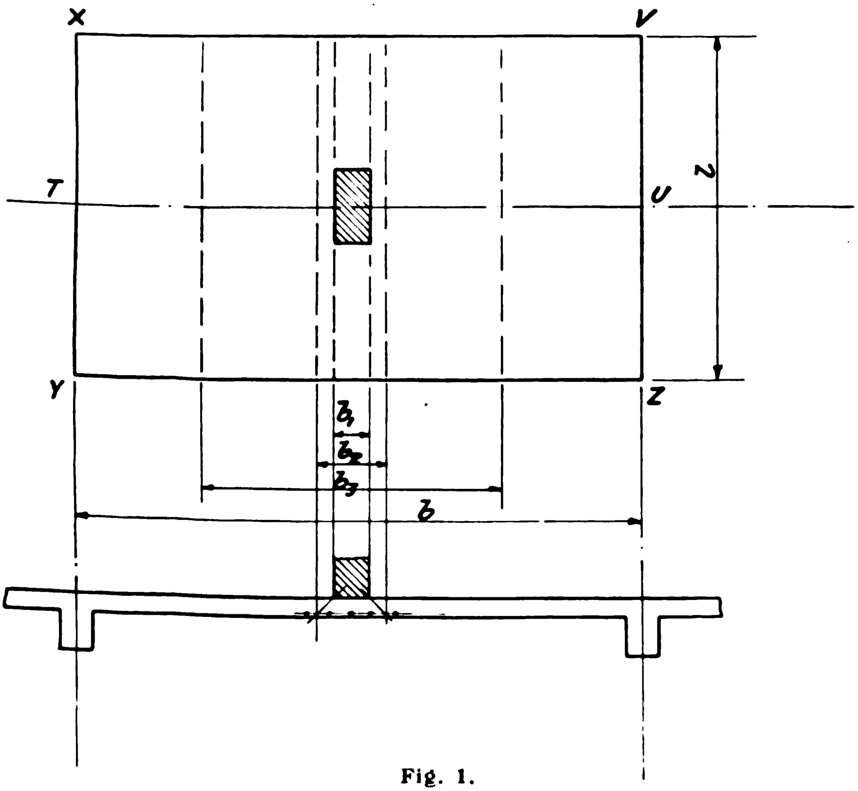


Fig. 1.

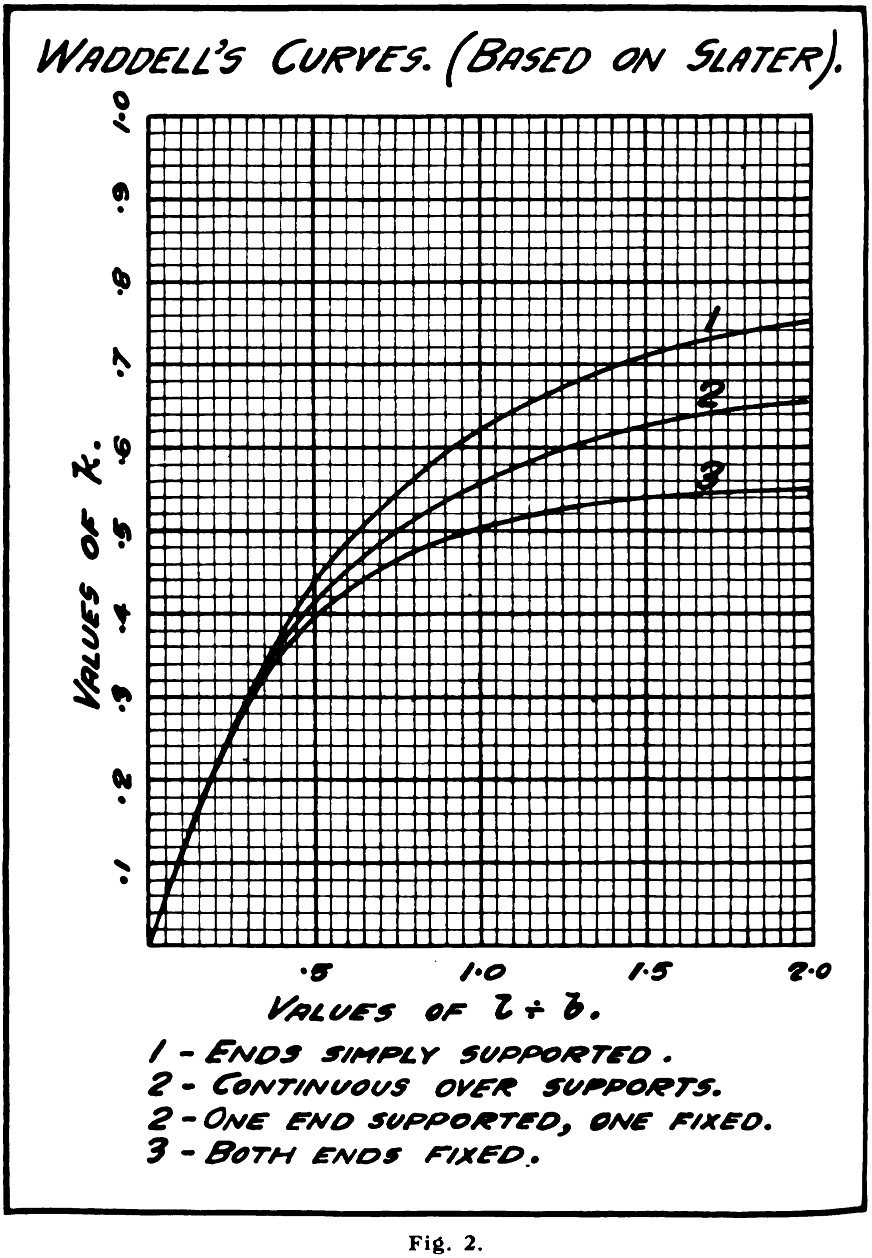

WADDELL'S CURVES. (BASED ON SLATER).
VALUES OF K.
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
·5
1·0
1·5
2·0
VALUES OF l ÷ b.
1
2
3
1 - ENDS SIMPLY SUPPORTED.
2 - CONTINUOUS OVER SUPPORTS.
2 - ONE END SUPPORTED, ONE FIXED.
3 - BOTH ENDS FIXED.

Fig. 2.

much difficulty at the maximum bending moment for which we are to design the slab.

The real problem is to decide the question, "What is the breadth of the slab which should be taken as resisting this bending moment?" We will consider three possible answers:

(1) The breadth of the load—shown as b_1 on the figure. This certainly errs on the safe side, but it is nearly as great a sin to be wasteful as to be hazardous in design.

(2) Next we have the value b_1 obtained by considering Clause 18 of the London County Council Regulations, which reads as follows:

> "For calculating the resistance moment the angle of dispersion of a point load through hard filling and concrete shall not be taken at more than 45 degrees from the vertical."

The wording of this clause can hardly be said to be masterly in its lucidity, but it is usually accepted that the intention is as follows: The breadth b_2 to be regarded as the breadth of slab to be taken in the calculation of the resistance moment to carry the bending moment caused by the load W is to be obtained by adding to the breadth b_1 twice the depth to the centre of reinforcement from the top of the hard surface.

It is now regarded as clear that in nearly every case this rule errs too much on the rough side.

(3) Finally we have a much greater effective breadth b_3 obtained by reasoning based upon experimental results. We will now consider some of the rules which have been put forward for the determination of the effective breadth b_3.

Waddell's Rule.—Mr. J. A. L. Waddell—a very safe guide in most structural matters—gives the curve shown in *Fig.* 2. This curve is based upon figures put forward by Mr. W. A. Slater as the result of some tests made at the University of Illinois; Mr. Waddell accepts Mr. Slater's main results, but varies them slightly as the result of tests made by the Highway Department of the State of Ohio.

For the present we will confine our attention to Curve 1, which is for slabs simply supported at the ends. The effective breadth b_3 of the slab over which the point load is to be considered to be spread is given by

$$b_3 = kl + b_1. \qquad (1)$$

This depends upon the total unsupported breadth XV of the slab and it will be seen that $k = 0{\cdot}7$ for a total breadth of 1·5 times the span, so that the result of using this curve is to give a much greater width of distribution for the point load compared with the L.C.C. rule. This means that the effect of a point load is much reduced, so that a floor slab designed for a given superimposed load will be able to carry quite a large point load placed at the centre.

The reasoning adopted by Waddell in arriving at the other curves is as follows: In the case of a slab fixed at both ends, there will be lines of contraflexure at the quarter points of the span, so that the centre portion is practically a simple beam of length $0{\cdot}5l$. If the slab should remain straight along these lines of contraflexure, the proper distribution width would be one-half of that for a simply-supported span. However, points on these lines directly opposite the load will deflect more than points on either side, which will increase somewhat the width of distribution. In the absence of any definite information it will be satisfactory to assume a value of *k* about three-quarters of that for a simply-supported slab, and the lower curve of *Fig.* 2 has been drawn on this basis ; but for a small value of total breadth divided by span it has been assumed that the distribution would be about the same as for a simply supported slab.

For a slab fixed at one end and simply supported at the other, the values of *k* have been taken as the average of those for the slab fixed at both ends and for the slab free at both ends.

Goldbeck's Rule.—Mr. A. T. Goldbeck gives, in a paper read before the American Concrete Institute in 1917, the results of further tests on the subject. (It should be mentioned that Mr. Slater's results, previously referred to, were given in the discussion of a paper read by Mr. Goldbeck in 1913 before the American Society of Testing Materials.) The procedure adopted was to measure, by means of extensometers—or strain gauges, as our American friends call them—the stresses in steel and concrete at various points along the centre section *TU* (*Fig.* 1) of the slab. From these a curve is plotted such as that shown in *Fig.* 2, and a rectangle of width of the same height as the curve is drawn so as to have an area equal to that of the curve. The width b_3 of this rectangle is the effective width of the slab over which the point load may be considered concentrated for the purpose of finding the reinforcement and stresses in the neighbourhood of the point load.

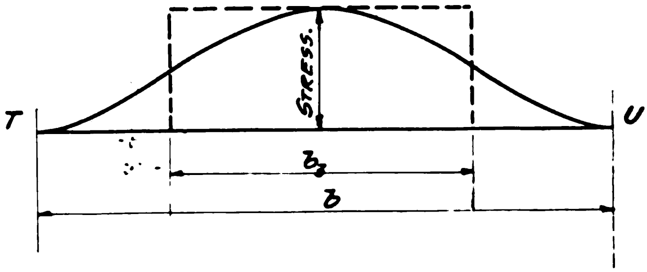


Fig. 3.

Fig. 4 gives Goldbeck's curve together with the experimental points, from which it will be seen that in fixing the curve a bias has taken in favour of the lower results.

In connection with Goldbeck's results it is interesting to note that the slabs which he tested had no transverse reinforcement (or distribution bars, as we usually call them), so that the distribution of the load which he found cannot be attributed to any special action of the distribution bars.

Proposed Rule for Practical Design.

From the results of the rules previously discussed the adoption of the following rules for practical design is suggested :

(*a*) *Spans simply supported at both ends*—

$$b_3 = b_1 + \cdot 7b \text{ for values of } b < l.$$
$$= b_1 + \cdot 7l \quad ,, \quad ,, \quad ,, \quad b > l$$

but b_3 never $> l$.

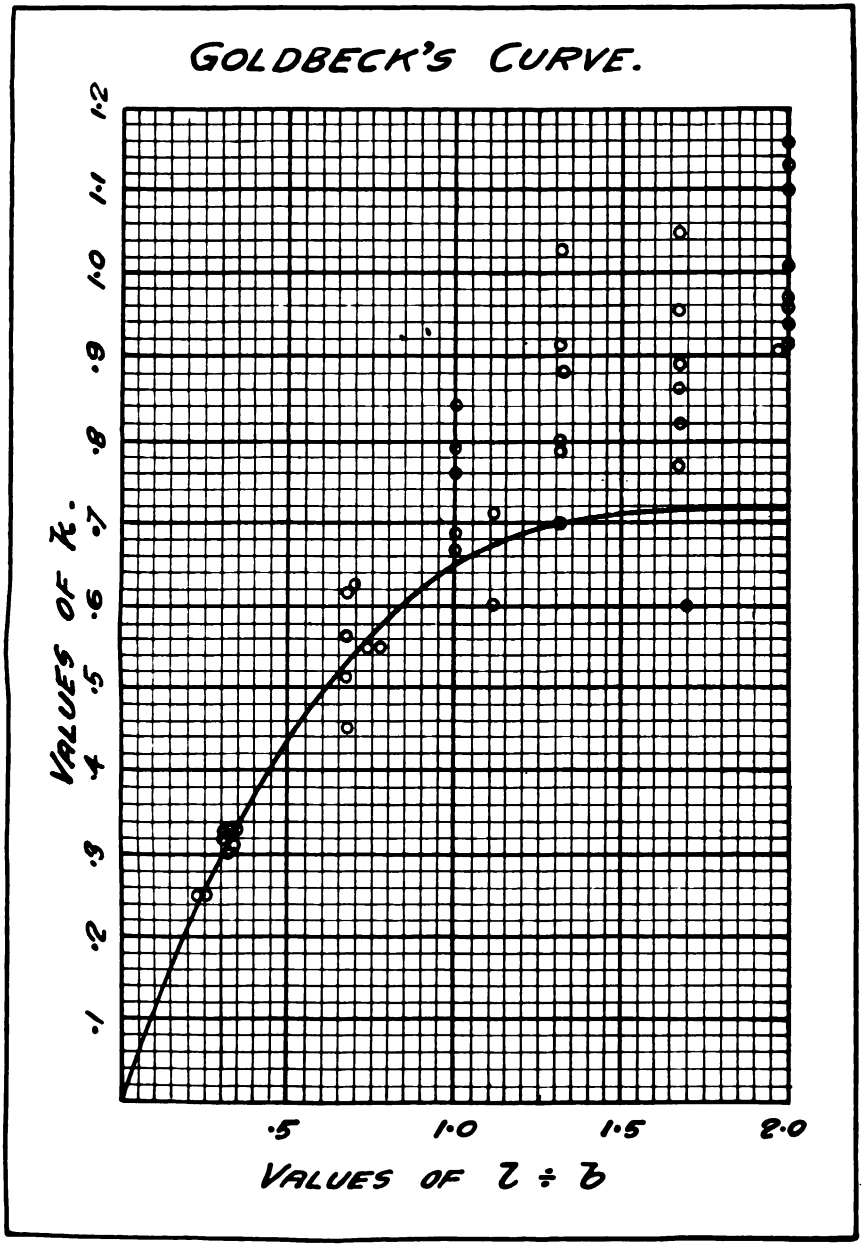

GOLDBECK'S CURVE.
VALUES OF K.
·1
·2
·3
·4
·5
·6
·7
·8
·9
1·0
1·1
1·2
·5
1·0
1·5
2·0
VALUES OF l ÷ b

Fig. 4.

(*b*) *Spans simply supported at one end; continuous at other*—

$$b_3 = b_1 + \cdot 6b \text{ for values of } b < l$$
$$= b_1 + \cdot 6l \quad ,, \quad ,, \quad ,, \quad b > l$$

but b_3 never $> l$.

(*c*) *Spans continuous at both ends*—

$$b_3 = b_1 + \cdot 5b \text{ for values of } b < l$$
$$= b_1 + \cdot 5l \quad ,, \quad ,, \quad ,, \quad b > l$$

but b_3 never $> l$.

It will be seen that these rules are a kind of blend of the Waddell and Goldbeck rules.

So far we have dealt only with the case in which the load is concentrated on a small area near to the centre of the span, this being in general the most serious condition for a single load.

In the case of a pair of equal loads at a given distance apart, such as we would have on a heavy lorry of a traction engine, it is suggested that the load be placed so that each is the same distance from the support, and that the above rules be used with the substitution of twice the distance from each load to the support for the value of the span l.

In the case of a slab carrying a narrow load, such as a wall or partition which extends from one support to the other, the writer suggests the adoption of the rule that the effective breadth be taken as three times the breadth of the load, or the breadth of the load added to three times the effective depth of the slab, whichever is the greater.

The new All-Concrete Croydon-Warlingham-Limpsfield Road.

[This concrete surface road has recently been completed for the Surrey County Council, under the direction of Mr. W. P. Robinson, the County Surveyor. It is 8 in. thick, reinforced with two layers of B.R.C. mesh.]

Reinforced Concrete Railway Tracks.

In our Editorial Notes we refer to the interest in the United States in the construction of reinforced concrete rail-beds on railways, in place of ballast, and we give below some notes on the design of such permanent track. This design is that adopted by the Pere Marquette Railway Co., which has now been completed and is in operation over a length of a quarter of a mile.

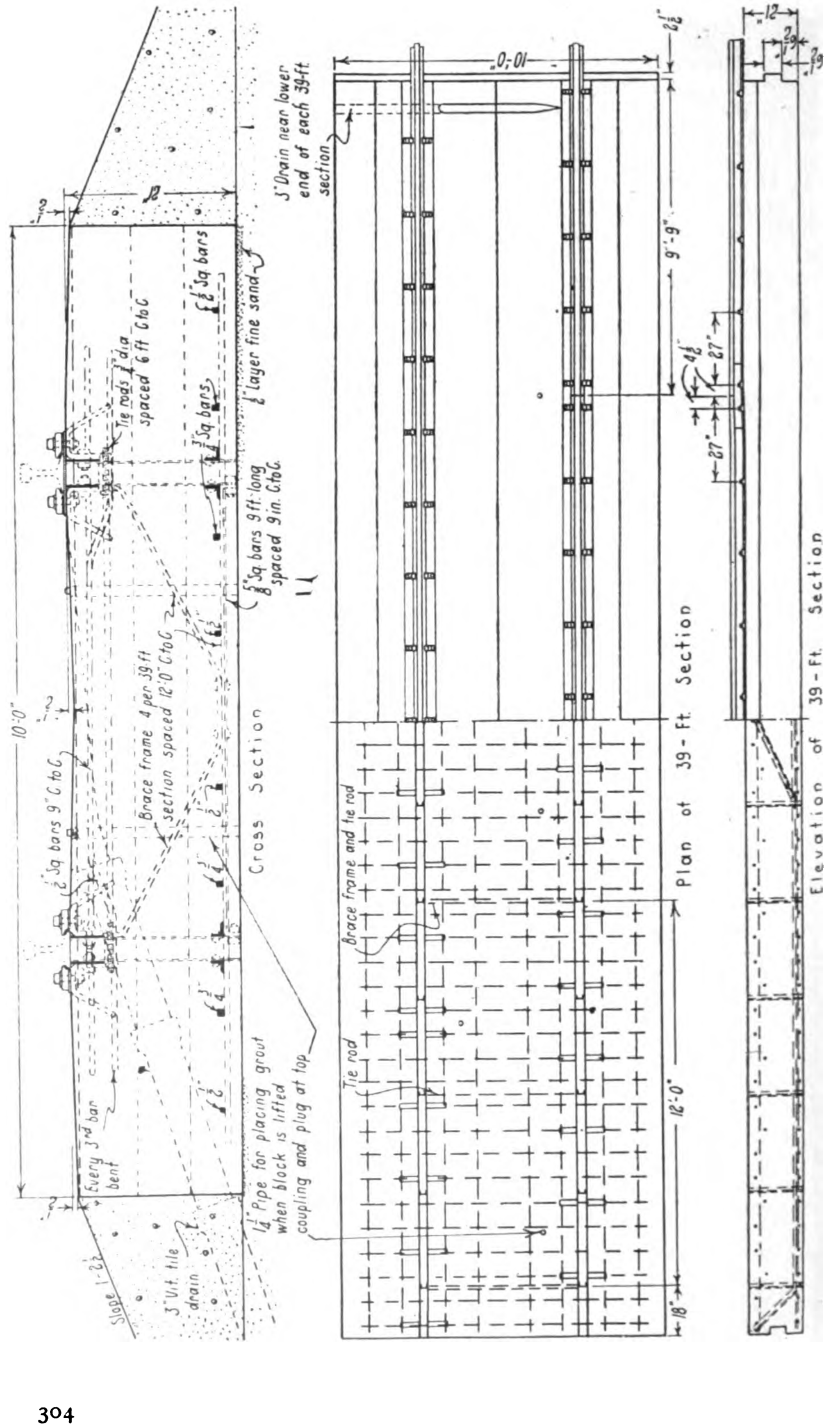
Reinforced Concrete Track Ready for Traffic.

Design of Track.—The supporting slab of concrete is 10 ft. wide and 21 in. thick. Assuming the use of 30-ft. rails, the concrete would be cast in sections of that length. The rail rests on the edges of two plates which are embedded in the concrete, and are perforated in order to provide better bond and more bearing on the concrete. These serve a threefold purpose: (1) To distribute the load and impact over a greater area of concrete; (2) to protect the concrete from shock and possible disintegration due to direct contact with the rail; and (3) to ensure a setting for the rail which is absolutely true as to line and surface. In addition, they form a guide for striking off the concrete surface in finishing.

The plates which form the rail seat also form the upper chord of a light truss, the lower chord of which serves as a part of the longitudinal reinforcement. The vertical members of this truss serve to anchor the rail seat to the concrete, and are extended below the lower chord so that they may rest upon stakes driven accurately to the elevation of the subgrade. This truss was shop-made, and the bracing and riveting are only of sufficient strength to prevent distortion while handling. When set in place, these trusses are connected by adjustable tie-rods spaced 6 ft. apart, and also by brace frames. Four of these brace frames are used for each 39-ft. section. One of the tie-rods forms the upper member of the brace frame. This arrangement gives a rigid framework which can be set accurately in place and will remain undisturbed while the concrete is being placed. It will also serve to transmit the loads into the mass of concrete.

Longitudinal reinforcement consists of four ¾-in. bars and four ½-in. bars in addition to the two 1½-in. by 1½-in. by ¼-in. angles which constitute the lower members of the trusses. The ratio of longitudinal reinforcement is about 0·37 per cent.

Transverse reinforcement consists of

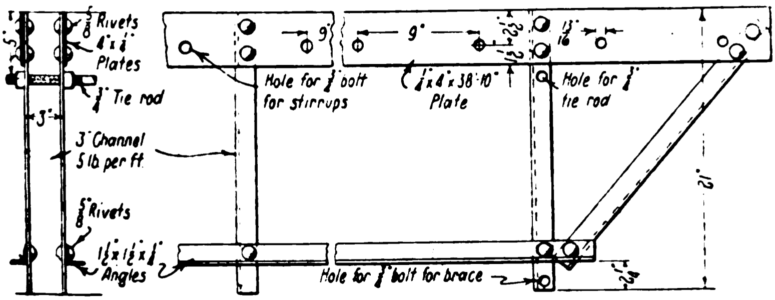

Cross Section
10'-0"
12"
2"
3" Drain near lower end of each 39-ft. section
1/2" Sq. bars
1/2" layer fine sand
Tie rods 3/4" dia. spaced 6 ft. C to C
3/4" Sq. bars
5/8" Sq. bars 9 ft. long spaced 9 in. C to C
1/2" Sq. bars 9" C to C
Brace frame 4 per 39-ft. section spaced 12'-0" C to C
Every 3rd bar bent
1 1/4" Pipe for placing grout when block is lifted coupling and plug at top
3" Vit. tile drain
Slope 1-2 1/2
Plan of 39-Ft. Section
10'-0"
2 1/2"
9'-9"
12'-0"
18"
Brace frame and tie rod
Tie rod
Elevation of 39-Ft. Section
12"
2 1/2"
27"
4 1/2"

Design of Reinforced Concrete Railway Tracks.

¾-in. square bars spaced 18 in. centre to centre near the base of the slab, and ½-in. square bars spaced 18 in. centre to centre, near the top of the slab. Where brace frames and tie-rods occur, other transverse reinforcement is omitted. Assuming the 70,000 lb. on a pair of drivers to be uniformly distributed over a longitudinal distance of 5 ft., and assuming an impact allowance of 50 per cent. and that the upward pressure of the subgrade is uniformly distributed, a unit tensile stress of 14,000 lb. for the steel and a unit compressive stress of about 300 lb. for the concrete are obtained.

These unit stresses are ample to take care of any increase in future loads, impact and unequal subgrade conditions. On account of the greater length of the section as compared with its width and the consequent opportunity for more variability in the condition of the subgrade, it is thought desirable to use a much lower unit stress for the longitudinal reinforcement than for the transverse. With modern methods of proportioning and making concrete the maximum of economy may be obtained through designing the concrete to meet the actual condition of stresses disclosed through experience in the use of this type of roadbed. It might seem that some economy in design could be attained by not using so thick a slab and using a higher percentage of reinforcement; on account of the impact, however, it is believed that the additional mass obtained by using a greater thickness is well worth its additional cost.

In order to facilitate construction, the concrete slab should be poured continuously and not in alternate sections. A metal separator is placed at the end of the section being poured. After the adjoining section has also been poured, this separator is then removed. It was not proposed to leave any well-defined joints between the sections, on the assumption that compression due to high temperature would easily be taken care of by the concrete, the thickness of which would prevent any tendency to buckle; and that tensile stresses would cause a cleavage at the end of each section inasmuch as none of the longitudinal metal is continuous. When these joints develop, they are to be filled with tar. In construction, the removal of the separator is delayed until at least a portion of the block ahead of it is poured, thus giving the block behind it a start towards setting and ensuring a cleavage practically along the plane of the separator.



Details of Reinforcing Truss.

The rail is held by rail-clips, which are attached by bolts to stirrups bolted to the perforated plates and embedded in the concrete. The bolt is placed with the head up and screwed into a nut which is inserted beneath the stirrup through a recess provided for that purpose. This recess is only slightly wider than the nut, thus preventing it from turning. This arrangement tends to lessen the danger of injury to the bolts in case of derailment, and permits their replacement if injury should occur. No angle bars or fish plates are necessary, as the rail seat and rail attachments serve their purpose.

With such a design, the rail no longer functions as a beam. A wearing surface and a base for bearing and attachment are all that need be provided, so that a much lighter rail may be used than at present. It is suggested that a 60-lb. rail would be fully as effective as a 130-lb. rail under present conditions.

Rail anchors are not needed. Creeping of the rail is avoided by keeping the bolts near the centre of the rail tighter than those at the end, or if this does not prove satisfactory, the rail could be anchored by one or two bolts near its middle point, thus ensuring the expansion and contraction of each rail as a separate unit. The only cushion between the rails and the concrete is a thin layer of oiled felt. This felt is treated with a bituminous mixture in order to preserve it. A layer of felt about $\frac{1}{8}$ in. thick, compressing to a thickness of $\frac{1}{16}$ in. under the tightening of bolts which hold the rail, and further compressing to perhaps one-half this thickness under an engine load, is expected to go far toward reducing the shock upon the concrete beneath the rail-seat, and also lessen the noise. Insulation between any two sections of track could be accomplished by substituting insulating fibre for the felt. This insulation should extend from the rail joint to the end of the concrete block.

Thorough drainage is essential. On fills made of sand no artificial drainage would be necessary, but on other fills it should be taken care of by tile drains just beyond the edges of the slab, with frequent outlets to the side of the embankment. In cuts the drains should be placed deeper and under the cut ditches, in order to prevent ground water from reaching the track. The proper functioning of these drains is a very important matter and they should be of ample size and have good outlet facilities.

Conduits for carrying all wiring, such as telegraph, telephone, block signals and train control, can be placed in the centre of the slab or elsewhere in the section if desired.

Cost.

The following estimate of cost is given, based on American prices and wages:

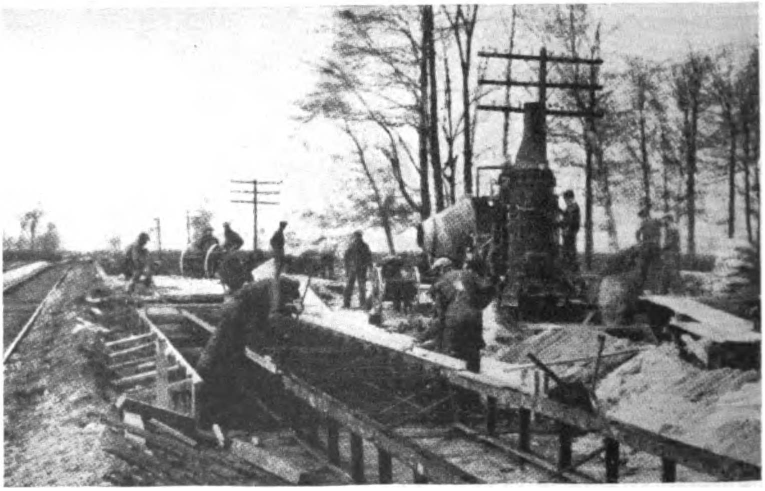
	per mile.
Rail and fastenings	£1,062
Concrete base	5,758
Total material	£6,820

The advantages that would result from a permanent track are classified as follows:

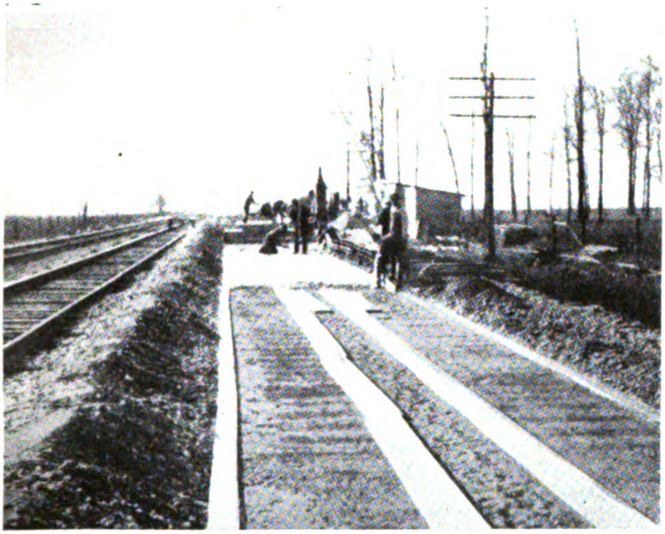
(1) Reduction in the cost of maintenance-of-way: (*a*) Ties eliminated, (*b*) Ballast eliminated, (*c*) Track labour reduced to rail renewals and track walking, (*d*) Probable reduced wear on rails and angle bars.

(2) Reduction in the cost of maintenance of equipment.

(3) Reduction in train resistance, resulting in: (*a*) Less fuel consumed, (*b*) Greater tonnage per train, with fewer trains; or higher speed with less train-hours.



Placing Reinforcement.



Levelling and Grouting Road-bed.

(4) Greater safety, especially at high speeds.

(5) More comfort for passengers, due to smoother riding and freedom from dust.

An estimate of the annual saving resulting from the first three of the above items on a track having a freight traffic of 30,000 gross tons per day and six daily passenger trains is given as follows (U.S. costs):

	per mile.
Maintenance of way	£335
Maintenance of equipment	305
Fuel	84
Increased tonnage rating	40
Total saving per mile per year	£764

This saving equals 10 per cent. of the estimated cost.

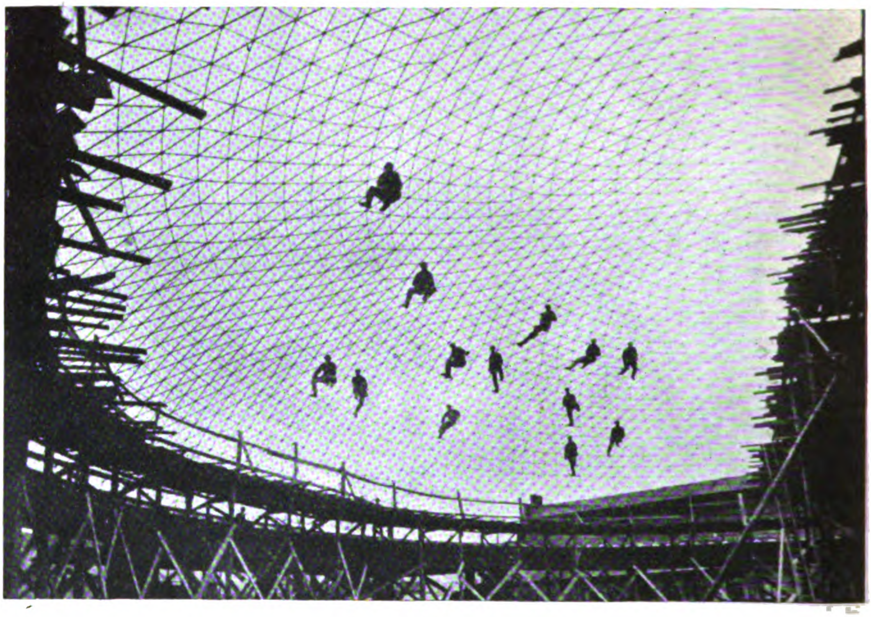
A similar estimate, based on a freight traffic of 40,000 gross tons per day, shows a saving per year per mile of £990 or 13 per cent. of the estimated cost.

It is assumed that the cost of maintaining equipment would be reduced 20 per cent., as it is reasonable to suppose that equipment running over a perfectly smooth track would require less repairs and would have a longer life than if subject to the innumerable shocks inherent in operation over the present type of track.

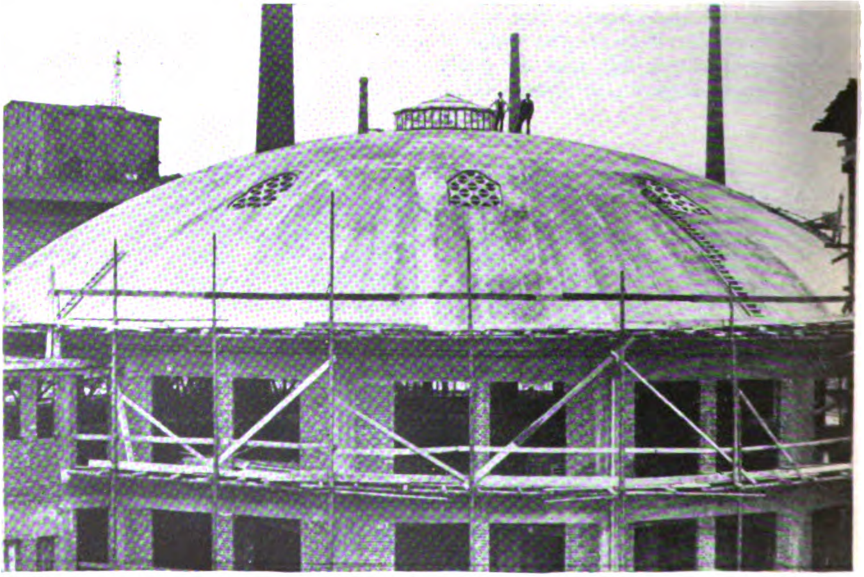
There is likewise no definite basis for the assumption of a reduction in train resistance. There is doubtless a large amount of energy lost in shocks at rail joints in the present track structure; and, due to the imperfect elasticity of the road-bed, a further amount is lost in depressing the track and pushing the main track wave ahead of the locomotive and smaller ones ahead of each truck. This loss would be practically eliminated with a track of the type proposed.

The Institution of Structural Engineers.

THE Annual Dinner of the Institution of Structural Engineers is to be held at the Piccadilly Hotel, London, on May 16, when Lord Carson will be the principal guest.



Fixing Reinforcement.



Completed Dome.

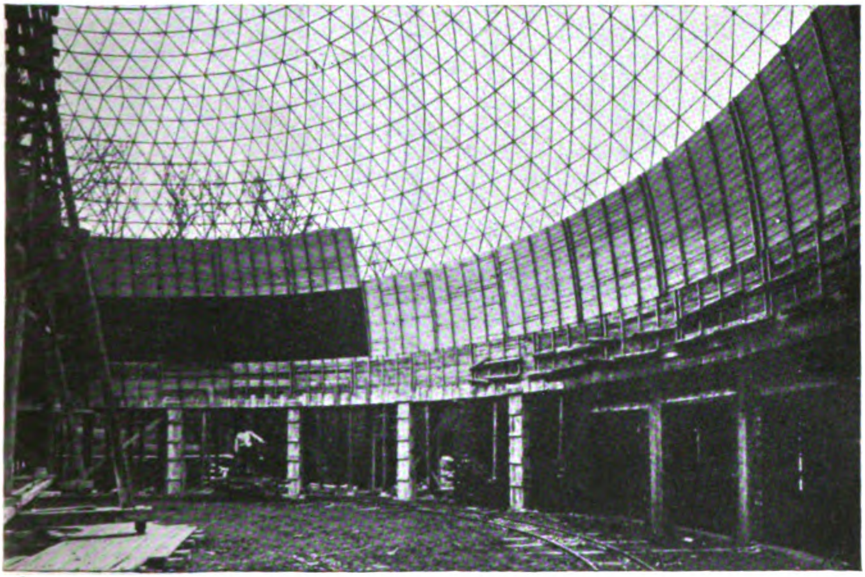
Construction of 131-ft. Span Dome at Schott and Gen Works, Jena.
(*See p.* 309.)

Novel Dome Construction.

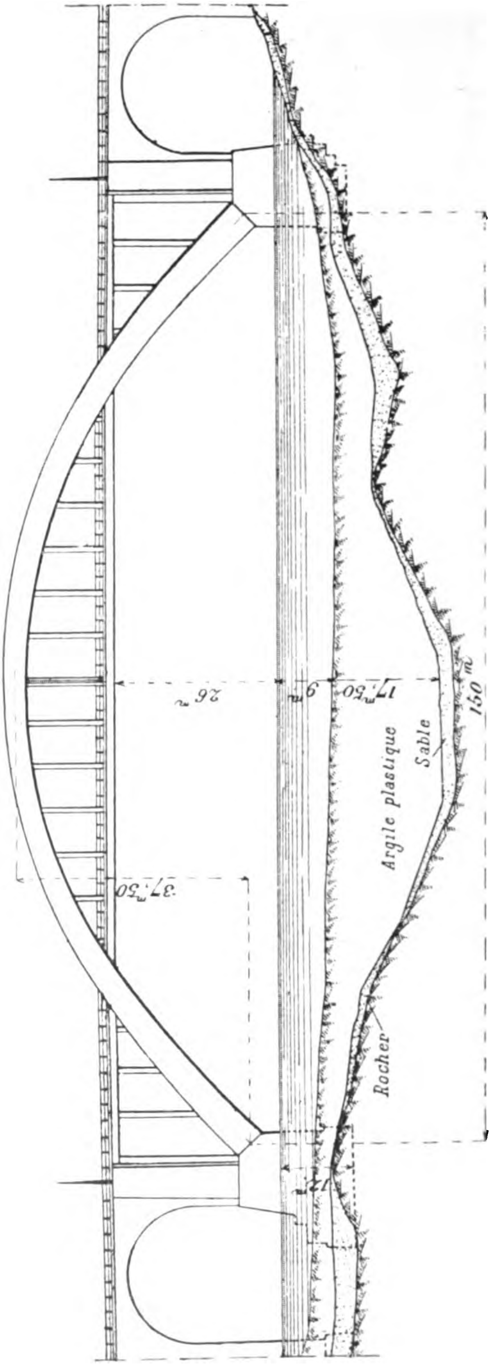
We illustrate two interesting reinforced concrete domes recently erected on the Continent on a system invented by Herr Bauersfeld, of the Jena firm of Zeiss, who also invented the planetarium. The system is patented by the Zeiss Company and the firm of Wyckenhoff & Widman.

The dome at the Zeiss firm's works was specially built for experimental work with the planetarium. It has a diameter of 52 ft. 6 in. and a thickness of 1⅛ in. The total weight is 35 tons. The reinforcement is so designed that its weight will be equal at all points, and to achieve this object flat steel bars 2 ft. long are used. These bars, of which there are 3,840 in the dome, are connected by means of two steel discs, bolted together, and containing grooves into which the bars are fitted. Each of the grooves is specially formed so that when the bars are assembled they conform to the curvature of the dome and are at the correct angle. The assembling of the reinforcement was commenced from the top, and when completed it was covered with a wire mesh against which the concrete was placed by a cement gun operated by men working in cradles suspended from the reinforcement.

The dome at the Schott and Gen Works is 131 ft. in diameter, and was built on the same principle. In this case the erection of the reinforcement was started at the bottom by men working from a scaffold pivoted from the centre of the dome so that it could be turned and raised as the work proceeded. The weight of the reinforcement in this dome is 13 tons, including a light system of round bars. The concrete, as in the case of the other dome, was placed by a cement gun, in courses from the bottom to the top. Aluminous cement was used to expedite the work. At each operation half the thickness of concrete was placed, the remainder being placed on each course immediately after the first layer had been placed on the course above.



Dome for Jena Planetarium.



Elevation of Bridge with Ljungberg Arch. (See p. 311.)

The Ljungberg Type of Arch.

In the construction of long-span bridges there are two well-known types, (*a*) the suspension bridge, and (*b*) the arch with either steel or reinforced concrete ribs. When a choice has to be made between steel and reinforced concrete for type (*b*) the latter is often preferred on account of its better resistance to weather even though its cost may be higher for spans above 100 ft. Clearly if the scaffolding necessary to support the formwork could be dispensed with, and if the chief members of the arch could be made of slender dimensions, reinforced concrete would have an advantage over steel.

In order to overcome the difficulty of costly scaffolding various means have been tried. Melan, using multiple lattice arches, built up from steel sections, suspended the formwork from these arches and concreted them in to form the reinforcement of the ribs. This system has been widely adopted in the United States.

In Germany and Austria Dr. Emperger's method of construction, employing cast-iron reinforcement at high stresses, is in more general use.

A third method, described recently in *Le Génie Civil,* has been worked out by M. Ljungberg of Stockholm.

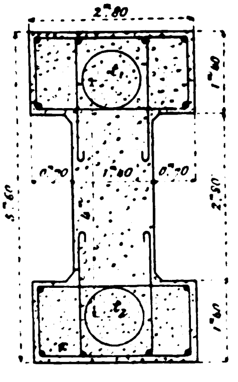
In this type of construction the principal reinforcement consists of steel tubes of suitable diameters connected by angle-iron diagonals. The tubes, which are delivered on the site in lengths of from 23 to 40 ft., are assembled there. When the halves of the arc are complete they are placed on barges and lifted by a crane, after which the key-joint is made. Such a skeleton frame is strong enough to support its own weight and that of the concrete cast around it.

Commencing at the springings the tubes are filled with concrete through openings, which are closed by cover-plates as the filling process proceeds. Care must be taken to see that the filling is complete so that there may be a perfect adhesion between the concrete and the tube which acts as a hooping reinforcement.

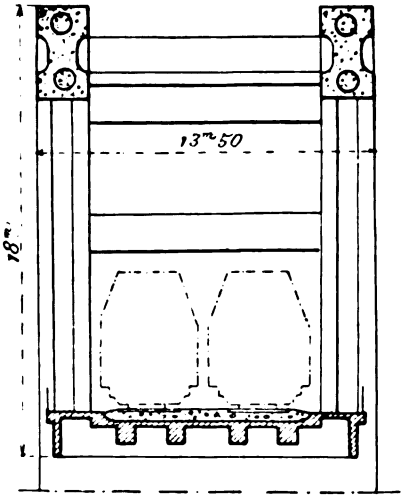
The formwork of the arch rib is suspended from the tube filled with concrete, and the rib is then cast (see section). Either Portland or high alumina cement may be used, the latter giving a more slender rib. The next operation is to pour the floor.

The advantages of this method of construction are, (*a*) the small quantity of steel used, the stress being high ; (*b*) the abolition of scaffolding or suspended centres ; (*c*) the higher carrying power of the concrete owing to its being enclosed in the tubes.

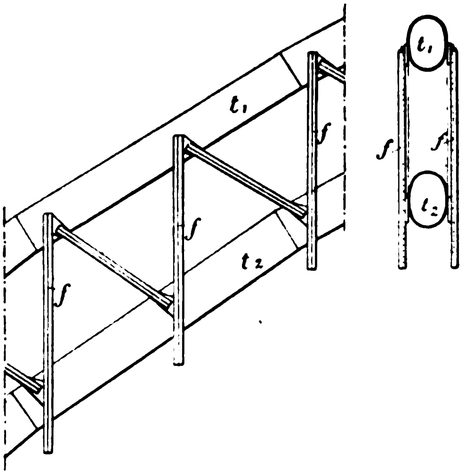
The strength of the compression members is undoubtedly greater than would be obtained by a simple hooping. As is well



Cross Section of Arch Rib.



Cross Section of Bridge.



Part Elevation of Tubes and Lacing Bars.

known, the hooping is in tension and prevents the transverse expansion of the column, consequently the concrete is submitted simultaneously to two compressive stresses. Under such conditions any material is capable of resisting a much higher compressive stress than if it were free to expand laterally. In fact, von Prandtl and von Karman have shown that a certain variety of marble had its ultimate resistance to compression increased from 19,500 lbs. per sq. in. to 80,000 lbs. per sq. in. by submitting it to a lateral compression of 23,600 lbs. per sq. in.

In this case the concrete within the tube will support higher loads than the outer coating, which will only withstand the ordinary compressive stresses if both the interior and exterior concrete are cast at the same time.

On p. 310 is the design for a bridge of 493 ft. span carrying two railway tracks. In Table 1 are given the stresses due to the various parts of the load. Thus there is a considerable saving in concrete as well as in scaffolding.—W. S. G.

f_s = steel stress at the crown in lbs./in.^{2}
f_c = combined concrete stress inside tube at crown in lbs./in.^{2}
f_c^1 = concrete stresses outside tube at crown in lbs./in.^{2}

TABLE I.

Stresses due to

	Wt. of Tube.	Interior Concrete.	Exterior Concrete.	Decking and Loads.	Total.
f_s . . .	2,560	4,550	12,250	6,830	24,700
f_c . . .	—	—	1,225	680	1,920
f_c^1 . . .	—	—	—	710	710

TABLE II.—QUANTITIES OF MATERIALS.

	Ljungberg Type.	Ordinary R.C. Arch.
Concrete	3,630 cub. yds.	4,670 cub. yds.
Steel	300 tons	300 tons

Reinforced Concrete Water Tanks.

Tanks Above Ground Level.

By **LESLIE TURNER, B.Sc., A.M.Inst.C.E.**

THE following designs are suitable for tanks holding up to 6 ft. depth of water at or about the temperature of the air.

The tanks may be of any convenient shape and of any size up to a side of, say, 50 ft., but not less than 6 ft. Such tanks fall under two heads, namely, those above ground and those below. Each is an entirely different structure from the other from the design, and therefore the constructional, points of view. The former type will be described in detail before passing on to underground tanks; in both cases, however, they are considered as open or uncovered, as the addition of a roof again modifies the design.

Tanks at or above ground level can be dealt with in the manner shown in *Figs.* 1 and 2. An important assumption must here be made, namely, that the ground at the level of the underside of the floor is of a reliable and consistent nature over the whole area of the tank, and is capable of withstanding safely a pressure of at least 1 ton per sq. ft. If there is the slightest uncertainty about this the ground should be excavated until a reliable stratum is reached and the excavation filled and levelled up with 1 : 3 : 6 concrete to the underside of the floor.

If the circumstances admit of the floor being lowered this may be done up to 1 ft. or so below ground level, in order to save the mass concrete, but it would also be essential to drop the top of the tank walls by a like amount so as not to exceed the 6 ft. maximum depth of water.

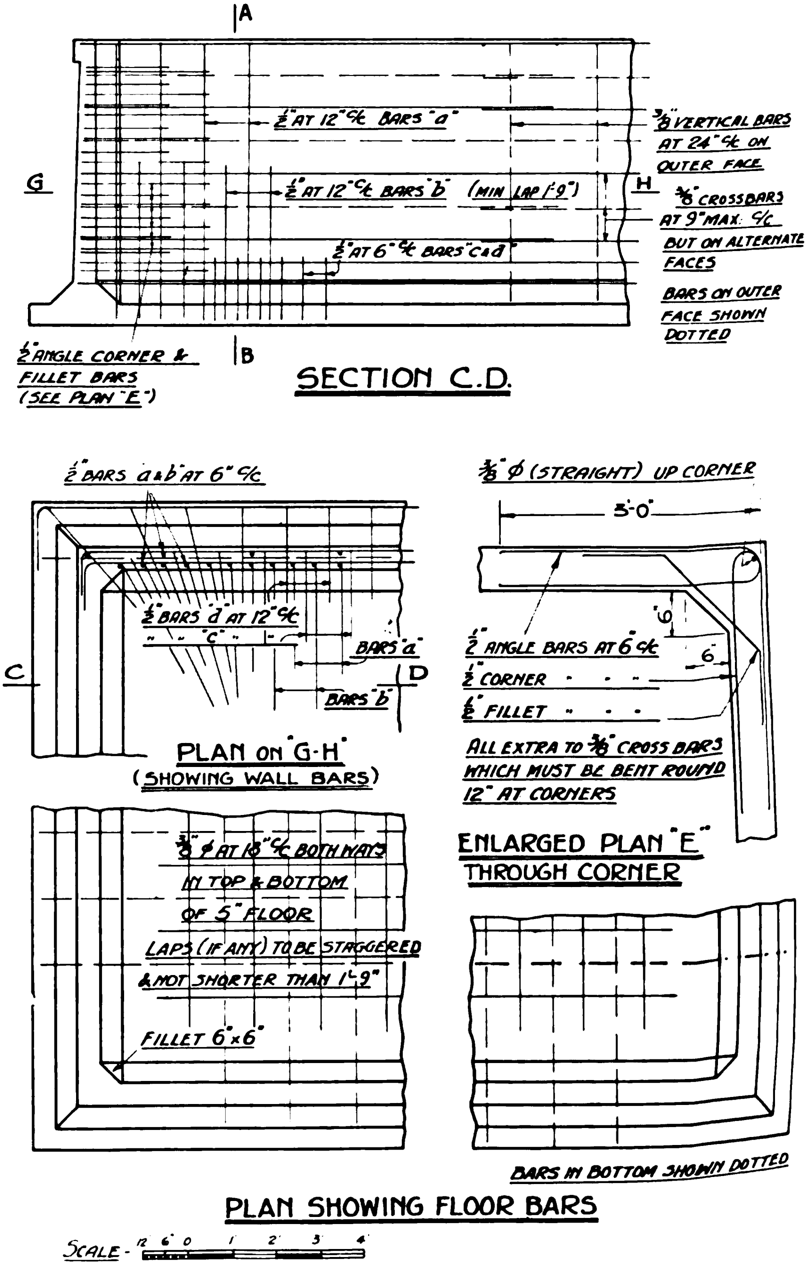
On the other hand, if it is desired to raise the tank a foot or two above ground, this may be effected by making up beneath with mass concrete as above; but this concrete must be continuous over the whole site, as the floor illustrated is only sufficiently reinforced for a continuous bearing and would not span over gaps or openings as a suspended floor.

Floor.

This consists of a 5-in. slab reinforced with $\frac{3}{8}$-in. bars at 18-in. centres both ways (at right angles) in the top and in the bottom of the slab. The bars should be wired together at their crossings into a mesh, and those nearest the surfaces given $\frac{1}{2}$ in. cover of concrete.

The upper layer is retained in position by small concrete blocks or metal spacers, which are moved along or taken out as the concreting of the floor proceeds. The lower layer can be supported on $\frac{1}{2}$-in. bars similarly moved along after the concrete has been thoroughly tamped around them.

If the floor is laid direct on ground and the latter is at all liable to work up into a slurry or mud, it is always desirable to cover the whole site


A
B
G
H
½" AT 12" C/C BARS "a"
⅜" VERTICAL BARS AT 24" C/C ON OUTER FACE
½" AT 12" C/C BARS "b" (MIN LAP 1'-9")
⅜" CROSSBARS AT 9" MAX. C/C BUT ON ALTERNATE FACES
½" AT 6" C/C BARS "c & d"
BARS ON OUTER FACE SHOWN DOTTED
½" ANGLE CORNER & FILLET BARS (SEE PLAN "E")
½" BARS a & b AT 6" C/C
½" BARS "d" AT 12" C/C
" " "c" "
BARS "a"
C
D
BARS "b"
⅜" φ (STRAIGHT) UP CORNER
5'-0"
6"
6"
½" ANGLE BARS AT 6" C/C
½" CORNER " " "
½" FILLET " " "
ALL EXTRA TO ⅜" CROSS BARS WHICH MUST BE BENT ROUND 12" AT CORNERS
⅜" φ AT 18" C/C BOTH WAYS IN TOP & BOTTOM OF 5" FLOOR
LAPS (IF ANY) TO BE STAGGERED & NOT SHORTER THAN 1'-9"
FILLET 6"×6"
BARS IN BOTTOM SHOWN DOTTED
SCALE - 12 6 0 1 2 3 4

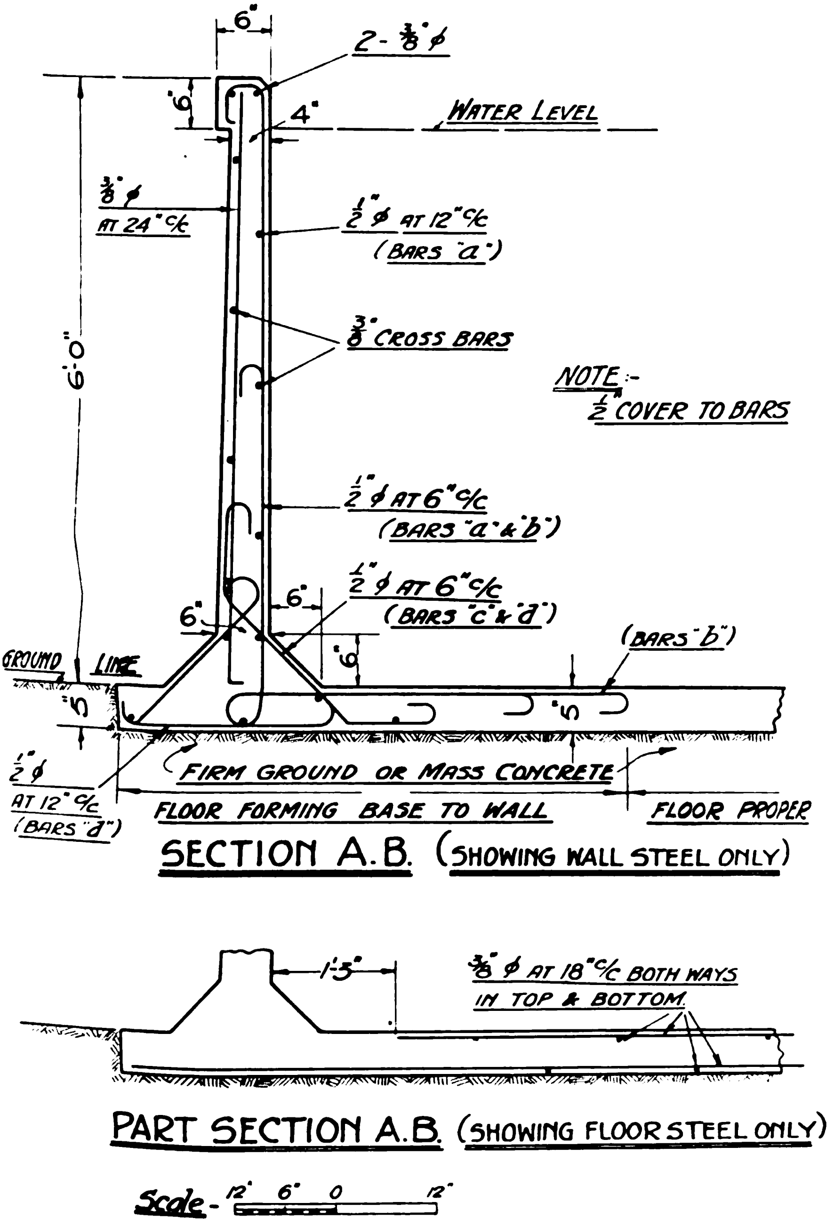
SECTION C.D.

PLAN ON "G-H" (SHOWING WALL BARS)

ENLARGED PLAN "E" THROUGH CORNER

PLAN SHOWING FLOOR BARS

Fig. 1.


6"
2-3/8"φ
6"
4"
WATER LEVEL
3/8"φ AT 24" c/c
1/2"φ AT 12" c/c (BARS "a")
3/8" CROSS BARS
NOTE:- 1/2" COVER TO BARS
6'-0"
1/2"φ AT 6" c/c (BARS "a" & "b")
6"
6"
1/2"φ AT 6" c/c (BARS "c" & "d")
6"
(BARS "b")
GROUND LINE
5"
5"
1/2"φ AT 12" c/c (BARS "d")
FIRM GROUND OR MASS CONCRETE
FLOOR FORMING BASE TO WALL
FLOOR PROPER
1'-5"
3/8"φ AT 18" c/c BOTH WAYS IN TOP & BOTTOM
Scale - 12" 6" 0 12"

SECTION A.B. (SHOWING WALL STEEL ONLY)

PART SECTION A.B. (SHOWING FLOOR STEEL ONLY)

Fig. 2.

with 2 inches of 1 : 3 : 6 concrete to form a firm working surface which will keep the reinforcement clean and prevent water from draining out of the floor concrete.

Concreting should be started at one end (outside the wall) and must be deposited for its full 5-in. thickness, well spaded and tamped, screeded to levels, and carried through to an approximately vertical joint at the end of each day's work.

The bars entering the floor from the wall (i.e. bars "a," "b," "c," and "d") must, of course, be placed and fixed before concreting commences.

In order to arrive at the lengths of the crossbars, set out the plan to scale, draw on the bars, beginning them where shown on Section AB. Arrange the laps (not to be shorter than 1 ft. 9 in.) so that they are staggered; that is, so that they "hit and miss" and do not all occur along any one section or line across the floor.

The fewer the laps and the longer the bars (up to, say, 25 ft.) the better, for economy in steel and from the point of view of strength.

In large tanks a fall will probably be required to the floor. This may be achieved by sloping the floor, say, 1 in. in 10 ft., upwards from the sump or lower end, or by screeding after a level floor has set.

A board, staked vertically, will be required around the perimeter of the floor as formwork.

Walls.

The shuttering for the wall must be rigid and self-supporting, and must be provided with loose boards on the outside so that concreting and tamping may be carried up in 1-ft. lifts.

The reinforcement as shown on the drawings must be carefully bent, placed, and securely wired and held so that it is not forced out of place during the pouring and ramming, particularly with regard to the ½-in. cover of concrete on each face. The notes relative to crossbars given under "floor" also apply here, and the two meshes should be separated by spacers made of small-diameter bars hooked or turned at their ends.

The wall indicated in *Fig.* 2 tapers from 6 in. thick at the bottom to 4 in. at the top. It may, of course, be made 6 in. thick all the way up, which simplifies the shuttering and its setting up at the expense of a little more concrete. The coping, projecting 2 in., should, however, be maintained from the point of view of appearance.

Special care must be exercised at the corners to ensure that the extra bars shown in plan E are concreted in correctly. The crossbars in the walls must also be turned round 18 in. on the outer face of the adjoining wall at the corners.

The horizontal portions of the wall bars may be gradually turned to radiate into the floor (as shown on plan GH) in order to avoid two sets overlapping.

Quantities.

As the size of the tank is undetermined, and to enable the quantities to be ascertained for tanks of any size or shape, the quantities are given

(1) per square yard of floor
(2) per linear yard of wall.

These amounts have only to be worked out for any particular case and multiplied by the following figures. *N.B.*—That area considered as Floor extends only from 5 ft. from the outside of the floor (i.e. from where the wall bars in the floor are stopped and hooked). Thus, if the ends of the floor were 20 ft. apart the area of floor would be computed as 10 ft. (20 ft. less two 5-ft. wall bases). The balance of the floor forms the wall base, and must be so considered from the point of view of quantities because it contains a heavier proportion of reinforcement.

FLOOR (*per yard super*) :—

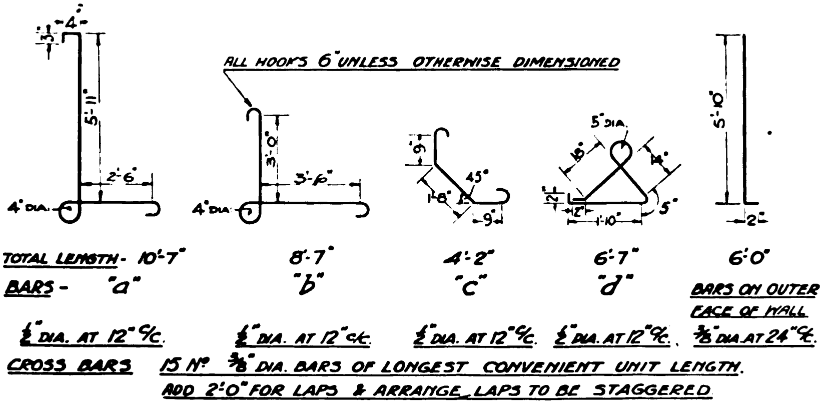
Shuttering—5-in. board round perimeter, staked.	
Concrete—9 sq. ft. 5 in. thick	3·75 cu. ft.
Reinforcement—⅜-in. bars at 18-in. centres both ways, in top and bottom straight, including a reasonable amount for laps . .	10 lbs.

WALL (*per linear yard*) :—

Shuttering—38 ft. super (both sides measured). Add for posts, struts and cutting

				cu. ft.
Concrete—Wall base (or floor)	15 sq. ft.	5 in. thick .	.	6·25
Fillets	6 lin. ft.	6 in. by 6 in.	.	0·75
Wall	18 sq. ft.	5 in. av. .	.	7·50
Coping	3 lin. ft.	6 in. by 2 in.	.	·25
				14·75

Reinforcement—approx. 83 lbs.



Special Note.—This design is based on the standard mix of 1 : 2 : 4 for the concrete, although a little richer mix may be used if desired.

In view of the fact that the concrete must be watertight, special care must be taken during mixing, placing, and punning, to produce a dense concrete. Joints must be well cleaned and grouted before the next day's concreting begins. With reasonable care the thicknesses given should be perfectly watertight, although slight seepage may take place when the tank is first filled. This, however, should "take up" in the course of a day or so.

The tank must not be filled for five or six weeks after the last pouring (if ordinary Portland cement is used) and the first filling should be gradual, extending over a day or two for fairly large tanks.

Concrete Roads in Palestine.

An interesting article on concrete roads has appeared lately in the Bulletin of the Association of Engineers and Architects in Palestine, which is published in English, German and Hebrew. The author of the article is Mr. S. Ettingen.

The importance of good roads in the development of Palestine has increased enormously of late years as the result of the increase of the cultured population of the country and the revolution in methods of transport. The development of industry and agriculture has also contributed towards a need for good roads.

The first concrete road was constructed in Palestine about four years ago, and up to the beginning of this year 120,000 square yards of concrete roadway have been laid down. At first the results were poor, owing to lack of experience and knowledge and the poor type of worker employed. In 1924 experienced workmen, machine mixers, and grading of aggregate were introduced with very satisfactory results.

First-class roads are laid to a thickness of 6 in. in two layers, of which the bottom is 1 : 2½ : 5 or 1 : 3 : 6 and the top 2 in. is 1 : 1½ : 3 or 1 : 2 : 3. Between the two layers there is reinforcement to the amount of 8¾ lbs. per sq. yd.

Second-class roads are 5 in. thick in two layers, the bottom 2 in. thick and of similar mixes to those adopted for first-class roads; 5½ lbs. of steel per sq. yd. are employed in this case.

Occasionally roads are laid in one layer 5 in. thick of 1 : 2½ : 4 or 1 : 1½ : 3 concrete with or without steel.

For the bottom layer, 2-in. broken stone aggregate and coarse sand, in volume proportions of 2 of sand to 3 of broken stone, are employed. This layer is lightly rammed, and after an interval of not more than fifteen minutes the second layer is placed. A harder quality broken stone aggregate is used in the top course, which is rammed, hand-rolled, and finished with a wide belt to the desired contour. For roads over 23 ft. in width a longitudinal joint is made.

The coarse aggregate for the upper course was wadi stone or stone with a compressive strength of from 8,500 to 14,200 lbs. per sq. in., of which 30 to 35 per cent. is from 0·2 to 0·6 in. and 65 to 70 per cent. from 0·6 to 1·4 in. The water used ranges from 7 to 8 per cent. of the volume of the stone and sand mixed. The mixing time is 1½ minutes.

Compressive tests of concrete for two roads gave the following results :

Mix.	Age.		Road A.	Road B.
Stone 21 cub. feet.	24	hours	1,400 lb./in.^{2}	—
10½ cub. feet.	3	days	2,220	3.350
Sand, 21 cub. ft.	7	,,	3,140	3.710
Cement, 880 lbs.	14	,,	3,725	4.110
,,	21	,,	4,550	4.020
,,	28	,,	5,300	5.590

For joint filling a mixture of asphalte and coarse sand was used. The number of joints is reduced when steel reinforcement is used, and in Palestine the spacing is usually 65 ft. when the slab is reinforced and 20 ft. for plain concrete slabs.

The writer complains of the heavy concentrated tire-loading which is permitted, and suggests a maximum wheel load of 2½ tons and a minimum tire width of 3 in.

W. S. G.

English and American Building Costs.

ONE of the leading American architects, Mr. Harvey Corbett, architect of Bush House, London, had much of interest to say in a recent address before the Royal Institute of British Architects, when he discussed the reasons for the fact that in spite of wages in the building industry in the United States being four or five times as high as in this country, the cost of building, per cubic foot, is practically the same in each country.

On his visit to London last summer, he said, he went carefully into the matter of costs for that particular type of commercial building represented by Bush House. He secured a complete tabulation of building production costs in New York and London—a practical list, not a supposititious one based on theory or guesswork—an analysis of which yielded some surprising results. At first glance the first list, relating to materials, appeared to show a slightly higher cost average in New York. Brick and sand, for instance, were about the same; wood was much more costly in London; but, on the other hand, limestone, similar to Bath, was more expensive in New York.

The second list, however, showing the cost of labour per working hour, revealed an enormous difference. Labour in New York was paid at least four to five times as much per hour as in London, four being a conservative estimate. For instance, a bricklayer in London received 1*s.* 9½*d.*, and in New York 7*s.* 3*d.*, and other rates were in the same ratio.

With these figures in mind, he was astonished to find that the cost per foot cube of finished commercial buildings was actually no more in New York than in London. In London prices per foot cube for various buildings still showed an increase of probably 120 per cent. over pre-war costs. A large modern office building of a substantial and efficient, but plain description, could not be built for a figure less than 2*s.* 1*d.* per foot cube. Examples were numerous at from 2*s.* 4*d.* to 2*s.* 9*d.* The larger and more ornate buildings varied from 3*s.* 3*d.* to 5*s.* per foot cube, according to the nature of the work, the character of the external elevation treatment, and the amount of decorative finish internally. If he were asked to give foot cube figures for these classes of buildings in New York, they would be practically the same in each case.

His task was, therefore, to explain how, with labour over four times as costly, they could build at the same final price for the finished structure.

There were four factors which went to make up the actual cost of a building. He said " actual cost " advisedly, because capital cost involved land values, fees, commissions on furnishing the necessary finances, taxes and interest during construction, and many other things. If they confined the discussion to actual cost, he believed they would not only have a fair basis of comparison between London and New York, but a relatively accurate basis of comparison for the whole of the British Isles and the whole of the United States. And the same comparison would apply to other building fields—residential, industrial, educational, governmental and religious—as well as to commercial construction.

The four factors of actual cost were :—

(1) Architects' and engineers' services.
(2) Contractor's organisation costs.
(3) Material.
(4) Labour.

The first item, architects' and engineers' services, was to all intents and purposes the same for New York and London, namely, 6 per cent. of the cost of the building.

The second item, contractor's organisation costs, might be assumed to be about the same. Although in America they had larger contracting organisations with greater overhead expenses, the volume of work done was proportionately greater. and hence the overhead charge against each job was proportionately less.

It was more difficult to determine whether the third item, material, became a natural increased cost in the completed building or not. The unit price cost was greater in New York than in London, but it would be readily understood that that would depend on the type of building, for in some the biggest item might be brick, in others stone, and in others steel. Wood in New York was much cheaper than in London, and while no wood remained in most of the finished buildings it was very extensively used in the process of construction. If this temporary wood could be ripped out and thrown away when it had served its purpose, as it was in America, labour was saved over the case where it was necessary for economy's sake to salvage each piece and preserve it for future use. However, he believed he was safe in assuming, all things considered, that material costs were about the same in the two cities.

Hence three out of four factors in the actual cost of building were seen to be about the same in London and New York. It therefore followed that the fourth, labour, must account for the great discrepancy which appeared to exist between the cost of production and the final cost. New York paid four times as much as London for labour, and yet the finished fireproof building, on a foot cube basis, cost practically the same.

One of two things must happen. Either in London a great deal more material was put in to produce a given foot cube, or American labour put in a great deal more material per working hour; either in London they built more substantially than necessary, or Americans erected buildings that were flimsy and insecure; either English organisation did not provide the facilities for labour to work efficiently, or American organisation gave the workman every chance to work at maximum speed.

He had watched British labourers at work, and he would hesitate to say that, when supplied with every opportunity for efficient effort, they were any less rapid than American labourers. In fact, operatives from the British Isles were among the best of all nationalities from which the New York building trades drew their labour.

There was no doubt in his mind that London practice was to build more substantially—heavier foundations, thicker walls, larger floor loads, and stronger steel. That alone explained part of the discrepancy, but not all. American builders estimated labour at 60 per cent. of the building cost, material at 40 per cent. In England that proportion must be more than reversed, labour being more nearly 30 per cent. of the building cost and material 70 per cent. Therefore an increase in the quantity of material per foot cube would, of course, affect the final building cost more than would an increase in labour wages. But, in spite of that, he felt that they must make a careful analysis, first, of the physical set-up of American buildings as compared with English, and second, of the organisation of the building industry in the two countries.

As far as physical set-up was concerned, the American problem was much simpler than the London. New York building plots were nearly all rectangular, due to the " grid-iron " plan of the city streets. London sites were irregular, with all sorts of angles, curves and notches. Æsthetically such a lay-out was undoubtedly finer, but practically the American was cheaper. It meant that they could use standard-sized steel forms, which were easier to assemble than irregular ones. They cost less because they could be manufactured in quantity, and they were easier to put in place. They saved money from the very plan of their cities.

The average life of a commercial building in New York City was said to be twenty years, and the semi-temporary nature of the construction was bound to influence the building to some extent. Americans were therefore inclined to build rather sparely without sacrificing efficiency and strength. The rapidity with which buildings were put up and torn down in America made one positively dizzy. Recently a popular caricaturist satirised this extraordinary situation by drawing a skyscraper with hordes of workmen around its base. The caption informed the reader that the building pictured was to have been finished in two weeks, but now the wreckers had arrived to tear it down again. This, the artist went on to say, was considered a great advance over the usual custom of waiting until three months after completion !

There were other things which made English material costs higher than those in New York. In London buildings were on earth and clay, which required spread footings in the foundation, whereas in New York they had to deal chiefly with rock ; and although rock might be more costly to excavate it required less in the way of substructure. Furthermore, he had noticed that in London they built a limited number of stories on foundations that were strong enough for many more.

But the chief physical saving in America resulted from the great size of building operations. On these huge structures, most of which were concentrated in a rather limited area, they were enabled to install systems which would be impossible in a series of small operations scattered at widely separated points. The new Greybar Building in New York, for instance, contained 22 million cubic feet and yet was built in a year and one month. It had 31 acres of carpet area, but covered only 68,000 sq. ft. of plot, for it was 31 stories high.

The increasing tendency in America was for owners to assemble larger and larger plottage whereon to put up larger and taller buildings. With those huge structures, a construction company in New York might do only four or five jobs in a year, and yet have a total annual volume of business amounting to six million pounds. To do six million pounds' worth of business in London, a contractor would have to spread himself over fifty, perhaps a hundred, jobs scattered all over the city, with a consequently increased overhead, and terrific confusion.

The crux of the whole situation was building organisation. They had probably heard over-zealous Americans rhapsodise about American efficiency and American business organisation until they were sick and tired of it. He didn't blame them. He was a little worn out by it himself. But the fact remained, they had it, and if they had not, costs would be prohibitive in the building world. When labour was 60 per cent. of final cost, delays mounted up in money with terrifying rapidity. So the big construction organisations had highly-paid men whose sole business was to prevent delays. These men did nothing but make weekly and even twice weekly inspections of the material during the process of its manufacture. They followed it up with as stern and anxious an eye as any trainer ever followed the progress of a Channel swimmer! The material must be finished on time, despatched on schedule, and delivered at exactly the psychological moment—no sooner, lest it clutter the streets and otherwise impede progress, and no later lest bricklayers and steam-fitters piled up wages without doing any work in return. The delivery of material to points on Manhattan Island was in itself a task of extraordinary complication, for much of it must change transport—rail, barge, and motor truck—several times before it reached its destination.

The whole progress of the building was scheduled with the same exactitude. When a labour gang was finished with a certain part of a building it was thrown to another part where the material was waiting for it, or to another building—all on schedule to the very hour and minute. Since most contracts in New York were accepted with heavy penalties for every day of delay in completion, the contractor must know pretty accurately just what the entire time schedule would be before the work was even begun.

The psychological aspect of the labour situation was another highly important, and oft-times amusing, matter. The labourer in the building trades received almost fabulous wages. By working overtime the labourer could make in a day as much as a stenographer or a clerk could make in a week. The universities were turning out thousands of trained men who went into banks and offices, and for several years earned considerably less than the man who had mastered a mechanical trade.

The result was he had become a gentleman labourer. He, too, was a white-collar man—after hours. When his eight hours were done, he returned to his comfortable flat, indulged in a shower bath, changed from overalls to a suit and sat down with his wife and children to a beefsteak dinner. In the evening, they went to a moving picture or a revue. In every sense he considered himself the equal, if not the superior, of the clerk who did not bear the stigma " common labourer," but who, the labourer knew, made a great deal less money. In fact, " common labourer " was hardly a term of reproach any more. Anyone who could earn $60 and more a week had the respect of the proletariat at least.

He had heard it said that in America the difference between a professional man and a business man was that one had a degree and the other had a Rolls-Royce. Similarly, the difference between the " white-collar " man and the labourer was that one had a " situation " and the other a bank account. Capital might still be king in America, but Labour was Prime Minister.

The psychological effect of this seemingly topsy-turvy condition was extremely interesting. It had given labour the dignity that must always go with financial independence. In England, the labourer was constantly aware of class distinctions. He took his orders without dispute, and dared not talk back to the boss. In America, he felt a certain sense of equality with his boss, or at least with his immediate overseer. If he did not like the way he was treated, he said so, and if he continued to be dissatisfied he quitted, always sure of finding another job. Of course, that made it difficult at times for the boss, but there was another side to the medal. He felt himself at liberty to make suggestions, which the labourer in England would never dare make. If he found some shorter, more efficacious, way of doing things, he spoke up, and if his superintendent was intelligent and the suggestion good, it was adopted. It gave him incentive. Many of the highly-paid executives in building concerns in America had come up from the ranks in that way.

A great deal was being done to make labourers do good and rapid work—perhaps too much. Recently a labourer working on one of the new Columbia University buildings was called before a large meeting in the auditorium and awarded a certificate of craftsmanship. The president of the University was there, together with officials of the building congress, architects and engineers. There were speeches of congratulation, and he was given a gold button to wear in his coat lapel. That did not mean that he received extra pay, or even a bonus, but it meant that he would never want for regular work. When he applied for a job, he simply had to show the gold button and he would be taken on without further question.

But the final effect that high wages had on the labourer was that it drew a higher class of men. They were more intelligent and efficient. Whether the present scale of wages was right and proper, or whether it was due to come a cropper some day, he was not prepared to say. But the fact remained that the unions had never from the beginning permitted a decrease in wages. And there still seemed to be plenty of work to be done.

To sum up, the reason why, with producing costs greater, the actual cost of the finished building in New York was practically the same as in London, was first, the physical set-up of the buildings themselves—standard rectangular forms, less material per foot cube, and less ponderous foundations. Also, the enormous size of the buildings made for concentration of effort, and permitted more efficient systems of handling material and labour to be installed. The very cost of labour had compelled them to devise ways and means whereby no labouring time was wasted. And, finally, the labourer himself was more satisfied with his lot, and was enabled to work more contentedly and more efficiently, and he had greater incentive to better his position in the world.

New Companies Registered.

Aerocrete Units (London), Ltd. (219784). Registered February 19. 97/98, Abbey House, Victoria Street, S.W.1. To enter into agreement with Aerocrete (Britain), Ltd., and Aerocrete Holdings, Ltd., and to carry on the business of manufacturers of concrete, concrete blocks, cement, etc. Nominal capital: £11,000.

Invictus Flooring Co., Limited (220462). Registered March 18. 53, Victoria Street, S.W.1. To enter into an agreement with Aerocrete Units (London), Limited, relating to the construction of floors. Nominal capital: £2,000.

Tricon Co., Ltd. (221160). Registered April 11. Manufacturers of concrete blocks and tiles, etc. Nominal capital: £2,000. Directors: F. C. Seymour, Ivy Hill, Queen Street, Hitchin; W. A. Seymour, Meryll, Lancaster Avenue, Hitchin.

Planning Formwork for Reinforced Concrete Construction.

By A. E. WYNN, B.Sc., A.M.Am.Inst.C.E.

The following notes on the organisation of formwork erection for reinforced concrete structures are from Mr. Wynn's book, " Design and Construction of Formwork for Concrete Structures," complete particulars of which will be sent by Concrete Publications, Ltd., on request.

THE common procedure of sending some timber and nails to the job and telling the foreman to get it built as quickly and as cheaply as possible is neither fair to the foreman nor conducive to efficiency and economy. If he happens to be a particularly good form builder and organiser the results may be satisfactory, but he will be an exception. More often than not there will be trouble somewhere, the forms will be too weak, cost too much, waste too much material, hold up other parts of the work, result in expensive finishing, etc., all of which could be avoided by a little careful planning ahead of the work and co-operation between the office and foreman in charge. The foreman's duty is primarily to organise labour and to get the work done. He should not in addition be expected to make form designs, draw sketches for the carpenters, and attend to details that could be done more efficiently in the office.

The busy contractor can only make periodic visits to his various jobs, so that while he is away he must be assured that the forms are being built sufficiently strong, economically, and with proper attention to details and planning of the work for maximum speed. The only way he can be sure of this is to have standard methods of building forms for different types of construction and to lay-out the work, design the forms, and make sketches of the several units in the office. The foreman then builds his forms according to blue prints as he would any other part of the structure, and he can devote most of his time to supervision of labour, in which capacity he can make the most money for his employer.

It is not meant that the foreman should have no say in the planning of the work, in the methods used, or in the details of construction. These matters should be decided upon in consultation with him in the office before the work starts; afterwards his main duty is to carry out the work according to pre-arranged plans and schedules. A few hours spent in the office will often save many lost days in the field.

The foreman is, in most cases, a better mechanic than the contractor or his engineer, and he can often suggest improvements in methods and details of construction which after trial can be incorporated in the standard plans. On the other hand, the foreman must be willing to co-operate with the office when he is asked to use different details than he has been accustomed to use. Continuous use of a certain method is apt to make a man think there is none other as good or better. Modern construction demands speed. Speed can only be attained by planning every step in advance and working to definite schedules.

The cost of formwork in a reinforced concrete building is approximately 20 per cent. of the total cost of labour and material. The whole progress of the work, and to some extent the cost of other items, will depend on the efficient handling of the forms. It should therefore be given the attention it deserves.

There are three distinct field operations to plan: (1) assembly; (2) erection; and (3) stripping. Each is dependent on the other, on the design of the forms, and the speed schedule for the job. On a small job the general foreman can look after all operations, but on a job of any size he should have a sub-foreman attending to each operation.

Speed Schedule.—After fixing the time allowable for the completion of the concrete frame, the number of days per floor or portion of a floor are determined. To maintain this rate of progress sufficient timber must be provided, depending upon the length of time the forms must be left in before stripping. Footing and foundation wall forms can always be used at least twice. One complete floor of column forms will be sufficient, as they can be stripped in two to three days. One complete floor of slab panels and beam sides is generally sufficient, though a floor-and-a-half may be necessary if the area is small.

Two floors of beam and girder bottoms should be provided, as the shores should be undisturbed for eight to ten days. As the second floor will probably be completely formed before the first floor shores can be removed, two-and-a-half floors of shores are generally necessary; this will allow work to go ahead on the third floor without waiting for shores from the first floor.

If the building covers a large area but is not very high, each floor can be divided into two parts and each treated in the same way as a separate story.

In order that the erection of the forms can start at the earliest possible moment, the timber must be assembled into panels in advance of the time they will be required. For maximum speed of erection and stripping as much as possible of the carpenter work should be done when making up the panels.

Office Detailing of Forms.—After deciding on the speed schedule required and the method of building the forms, all parts or "panels" that can be assembled in advance, and timbers that have to be cut to length, should be sketched out on paper, showing all the details necessary and the number of pieces required of each kind. This may seem like a lot of work, but if the designs and details are standardised and the detailing done according to a system it can be done very quickly.

After a method of construction has been found to be satisfactory and to give low costs there is no reason why it cannot be made a standard for all similar work. Standardisation will improve the efficiency of the workmen, as they will soon learn how to go ahead without waiting to be told what to do. It will enable closer costs to be kept and better

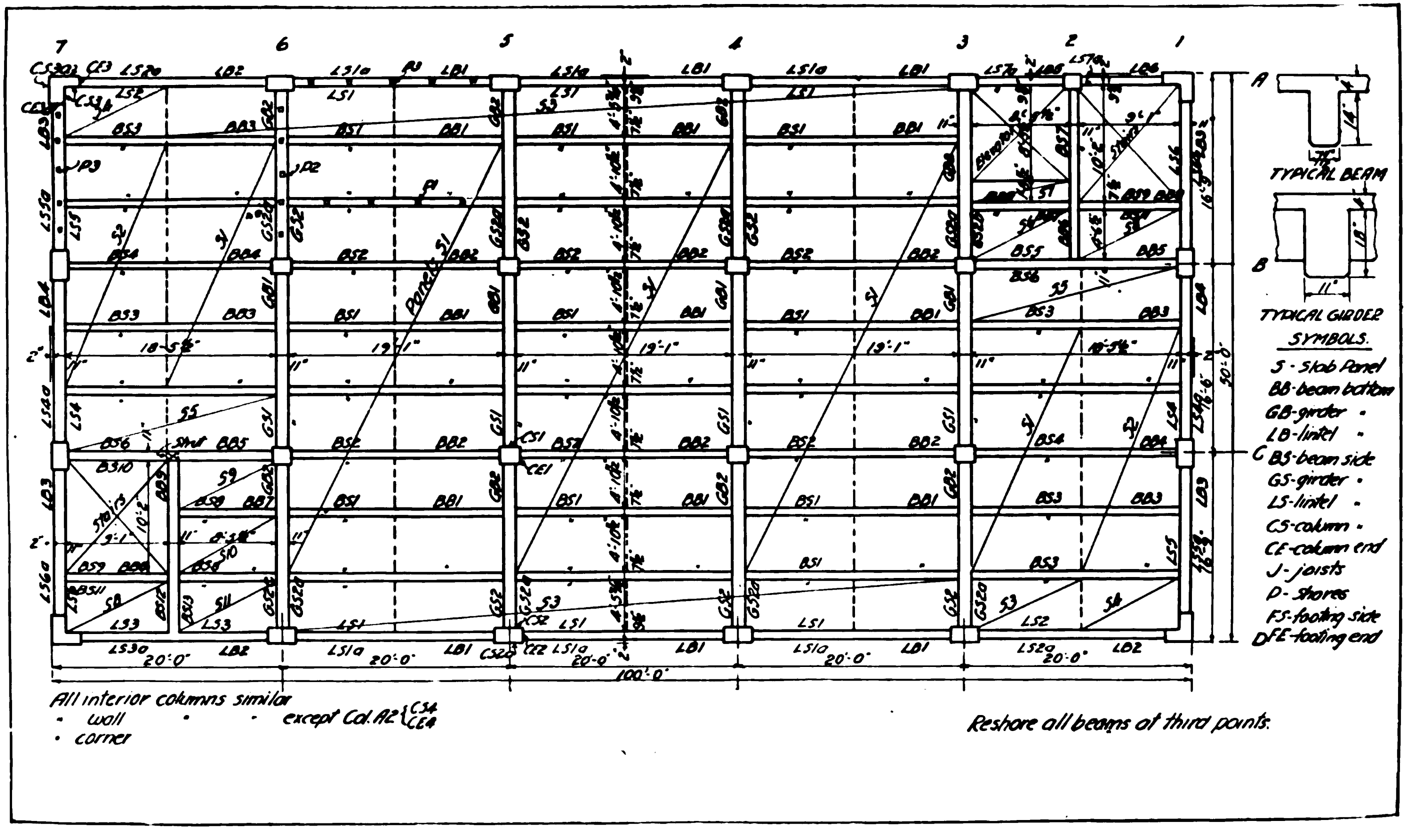


Fig. 216.—KEY PLAN TO PANELS FOR 5-STORY BUILDING.

comparisons to be made of the output of the workmen and the efficiency of the foremen. It will reduce the waste in material to a minimum, since timber ordered in sizes and lengths economical for one method of construction may be quite uneconomical if another method is used. Detailing the panels in the office will eliminate mistakes in the field and much waste time of expensive workmen, since the assembly carpenters will have their work laid out for them on paper and they will not be waiting for instructions on the sizes required, the method of building, and the number of panels to make. The foreman's time will be conserved for organising. The detail sheets will show the stock lengths ordered for the different panels, so waste of timber will be prevented.

The detail sketches and number of pieces required will also be necessary for the intelligent ordering of the timber.

The detail sheets should be made in the order in which they are required on the job, unless there is time to make up the whole set before they are needed. Rough sketches are first made of the typical panels and timbers and the number of each calculated so that the bill of material can be got out as soon as possible. Some allowance must be added for waste, breakage, and repairs.

The sketches are then drawn out in more detail on special detail sheets, showing all the information necessary for the building of the panels, the number required, the stock lengths ordered, the changes necessary on other floors and any notes that will aid the erecting foreman.

Many of the panels necessary can be tabulated on one sheet, as they will be built similarly, only varying in dimensions. For instance, all beam sides will be similar; their length and depth may vary, but one sketch will do for all. Of course, here and there special panels will be required, for which individual sheets must be made out.

It is possible to standardise these detail sheets so that from the tracings white prints can be made on which the details are filled in. Sketches need not be made to scale, as all necessary dimensions are shown. Sheets should be a convenient size, not larger than 8 in. by 10 in., and preferably smaller. Only one kind of panel should appear on each sheet.

A standard system of symbols is necessary in order to identify the panels. The symbol of each panel is marked on the sheet and also on the finished panel. These symbols are tied in to a key plan, which is used for erection purposes. One key plan is sufficient if all floors are alike, since any necessary changes in the forms can be shown on the detail sheets. If the floors are different a key plan will be necessary for each different floor.

This plan is drawn, taking a section between floors looking up at the floor above, and shows the outlines of the concrete members only. All panels required are indicated on this plan by symbol. Although originally drawn to a large scale it should be reduced to a convenient size for handling on the job.

A simple system of symbols easy to remember is S for slab panel, BB for beam bottom, BS for beam side, CS for column side, FS and FE for footing side and end, etc. A number added to the symbol indicates the location on the key plan, and if it is necessary to show the floor on which a panel is to be used the number of the floor precedes the symbol; for instance, 3BB12 indicates the beam bottom for beam 12 on the third floor. Panels that are similar are given the same symbol.

The method of making the detail sheets can best be shown by taking an actual example, say, of a reinforced concrete factory. It is assumed that the reader has followed the previous chapters, showing how to obtain the sizes and spacing of timbers, the provisions to make for easy stripping, clearances and other details. *Fig.* 216 shows a key plan for a typical floor of a 5-story factory, 50 ft. by 100 ft. in size. The lay-out and beam sizes on all floors and roof are kept the same—which is good practice—so that one key plan does for all floors. The column sizes change from floor to floor, and the changes required to the panels are shown on the detail sheets. Following the key plan are shown typical detail sheets, covering most of the panels required for the building. Twenty sheets would cover all the panels necessary. More notes are given than would be required if the carpenters and foreman were familiar with the system. The stock lengths for ⅞-in. boards are not given, because this size is generally ordered in random lengths varying from 10 ft. to 16 ft. Since much of this has to be cut up in short lengths there is little waste.

The system of construction used is (*see* Chapter IX) slab panels resting on loose joists carried on continuous ledgers; beam bottoms carried on girder or column sheathing; beam sides and girder sides built with about 1½ in. clearance at each end for bevelled keys. Additional sheets can indicate the size and number of braces, ribbons, etc.

Assembly.—The timber pile, saw table, and assembly bench should be placed together in a location where there is plenty of storage space and where a minimum amount of handling of the panels will be required. The relation of each to the other should be such that the timber will pass in one direction through the sawmill and assembly bench to the stock-pile, which should be nearest the structure.

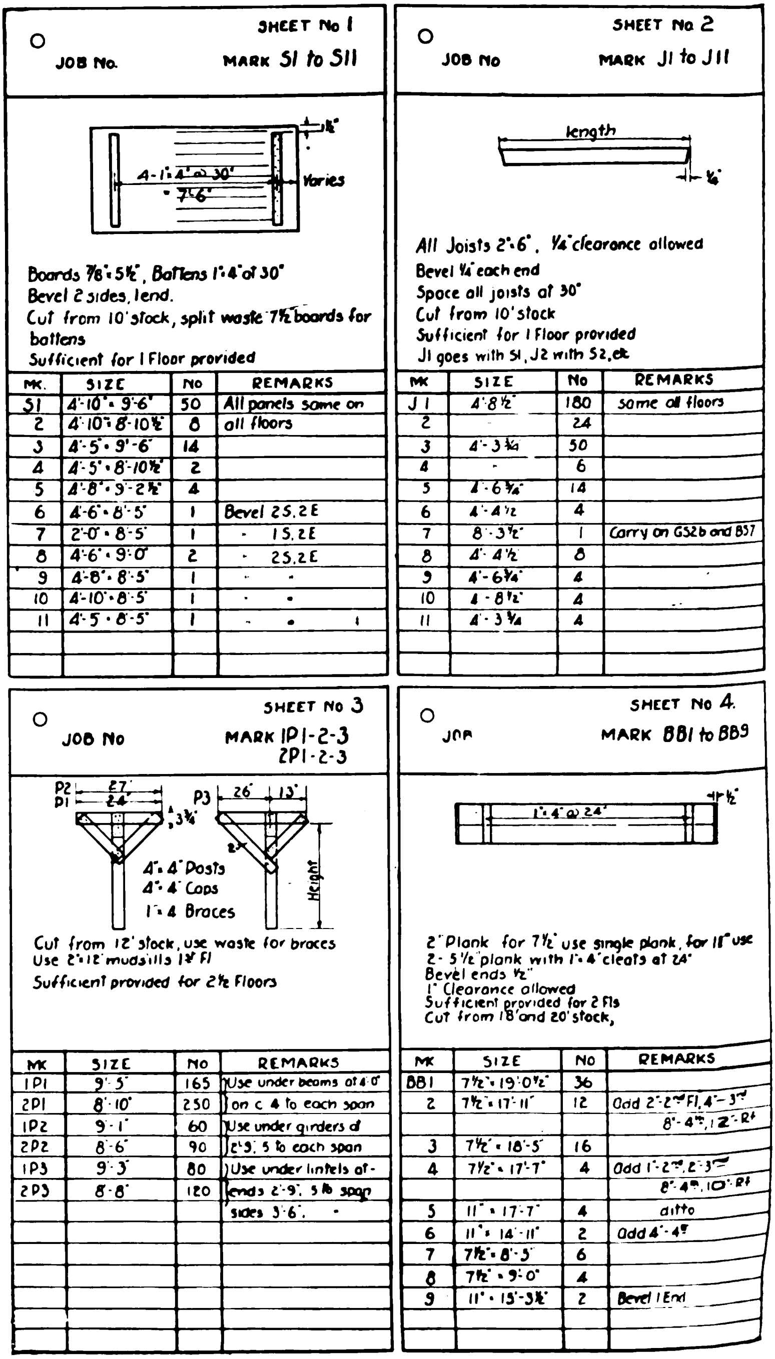
If the job is large enough a sub-foreman should be in charge of all assembly, from delivery of the timber to the sawmill to delivery of the finished panels to the erecting carpenters.

Copies of the detail sheets go to the saw operator and to the assembly carpenters. The foreman picks out the timber required, which is carried to the saw table, where it is sawn to the required lengths, and passed on to the assembly bench where it is made up into panels.

Battens, cleats, etc., should be sawn first, so that they are ready at the bench when the boards are received.

The foreman must study the order in which the panels will be required so that there will always be a sufficient number of each kind required ready for the erectors.

As the panels are completed they should be marked with their symbols, oiled, stacked, and moved to their location in the building as required.


4-1"×4" @ 30"
× 7'-6"
Varies
½"
length
¼"
P2
P1
27"
24"
P3
26"
13"
3¾"
2"
Height
1"×4" @ 24"
½"

SHEET No 1

○ JOB No. MARK S1 to S11

Boards 7/8"×5½", Battens 1"×4" at 30"
Bevel 2 sides, 1 end.
Cut from 10' stock, split waste 7½" boards for battens
Sufficient for 1 Floor provided

MK.	SIZE	No	REMARKS
S1	4'-10"×9'-6"	50	All panels same on
2	4'-10"×8'-10½"	8	all floors
3	4'-5"×9'-6"	14	
4	4'-5"×8'-10½"	2	
5	4'-8"×9'-2½"	4	
6	4'-6"×8'-5"	1	Bevel 2S, 2E
7	2'-0"×8'-5"	1	" 1S, 2E
8	4'-6"×9'-0"	2	" 2S, 2E
9	4'-8"×8'-5"	1	" "
10	4'-10"×8'-5"	1	" "
11	4'-5"×8'-5"	1	" "

SHEET No 2

○ JOB No MARK J1 to J11

All Joists 2"×6". ¼" clearance allowed
Bevel ¼" each end
Space all joists at 30"
Cut from 10' stock
Sufficient for 1 Floor provided
J1 goes with S1, J2 with S2, etc

MK	SIZE	No	REMARKS
J1	4'-8½"	180	same all floors
2	"	24	
3	4'-3¾"	50	
4	"	6	
5	4'-6¾"	14	
6	4'-4½"	4	
7	8'-3½"	1	Carry on GS2b and BS7
8	4'-4½"	8	
9	4'-6¾"	4	
10	4'-8½"	4	
11	4'-3¾"	4	

SHEET No 3

○ JOB No MARK 1P1-2-3
2P1-2-3

4"×4" Posts
4"×4" Caps
1"×4 Braces

Cut from 12' stock, use waste for braces
Use 2"×12" mudsills 1st Fl
Sufficient provided for 2½ Floors

MK	SIZE	No	REMARKS
1P1	9'-5"	165	Use under beams at 4'-0"
2P1	8'-10"	250	on c. 4 to each span
1P2	9'-1"	60	Use under girders at
2P2	8'-6"	90	2'-9", 5 to each span
1P3	9'-3"	80	Use under lintels at-
2P3	8'-8"	120	ends 2'-9", 5 to span
			sides 3'-6". "

SHEET No 4.

○ JOB MARK BB1 to BB9

2" Plank for 7½" use single plank, for 11" use
2-5½" plank with 1"×4" cleats at 24"
Bevel ends ½"
1" Clearance allowed
Sufficient provided for 2 Fls
Cut from 18' and 20' stock,

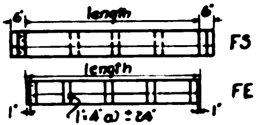
MK	SIZE	No	REMARKS
BB1	7½"×19'-0½"	36	
2	7½"×17'-11"	12	Add 2'-2" Fl, 4'-3"
			8'-4", 12'-Rt
3	7½"×18'-5"	16	
4	7½"×17'-7"	4	Add 1'-2", 2'-3"
			8'-4", 10'-Rt
5	11"×17'-7"	4	ditto
6	11"×14'-11"	2	Add 4'-4"
7	7½"×8'-5"	6	
8	7½"×9'-0"	4	
9	11"×15'-3½"	2	Bevel 1 End

FIG. 217.

SHEET No. 5

○ JOB No.

MARK FS1-2-3-1a-2a
FE1-2-3-1a-2a



⅞" × 5½" or 7½" boards, 1" × 4" battens at 24"

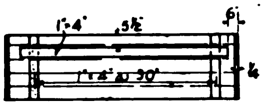
Sufficient panels for ½ Footings

MK	SIZE	NO	REMARKS
FS1	14" × 8'-1⅝"	8	
1a	14" × 5'-1¾"	8	Interior Step Foot'g
FE1	14" × 8'-0"	8	
1a	14" × 5'-0"	8	
FS2	11" × 6'-9¾"	12	
2a	11" × 4'-8¾"	12	Wall Col Step Foot'g
FE2	11" × 5'-6"	12	
2a	11" × 3'-5"	12	
FS3	14" × 4'-7¼"	4	Corner Cols and
FE3	14" × 4'-6"	4	Col A2

SHEET No. 6

○ JOB No.

MARK BS1-4-6-8-9
11-2-3.



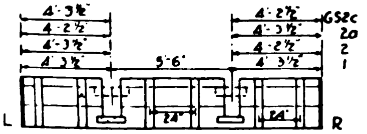
Boards ⅞" × 7½", Battens 1" × 4" at 30"
Ledger 1" × 4", Keys 2" × 4" × Depth of side
Tack 2 keys to each side
Bevel each end ¼"

MK.	SIZE	NO	REMARKS
BS1	14⅞" × 18'-9"	36	Same all Floors
2	14⅞" × 17'-7"	12	Increase length 2" on
			2⅞, 4-3⅞, 8-4⅞, 12 · Rf
3	14⅞" × 18'-1½"	16	Same all Floors
4	14⅞" × 17'-3"	4	Incr. 1-2⅞, 2-3⅞, 8-4⅞, 10 R
6	16⅞" × 17'-3"	2	ditto
8	12⅞" × 8'-1½"	6	Same all Floors
9	17¾" × 8'-9"	2	ditto
11	12⅞" × 8'-9"	2	ditto

NO 7

○ JOB No

M. 1-2-2a-2c.



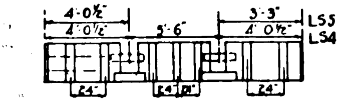
Boards ⅞" × 7½", Battens 1¼" × 4" at 24". Cleats 2" × 2"
Provide 2 keys 2" × 4" × 18⅞"
Bevel Ends and Sides of Openings ¼"
Openings 8" × 14⅞" except GS2c - 8" × 12⅞"
Tack cleats over openings

MK	SIZE	NO	REMARKS
GS1	18⅞" × 14'-1"	8	Add 1" L & R - 2⅞, 2 L & R - 3⅞
			4" L & R - 4⅞, 6 L & R - Rf
2	18⅞" × 14'-0"	6	Add 1" L - 2⅞, 2 L - 3⅞
			4" L, 4" R - 4⅞, 6 L - Rf
2a	18⅞" × 14'-0"	8	Reverse to GS2
2c	18⅞" × 14'-0"	1	Same as GS2

SHEET No 8

○ JOB No

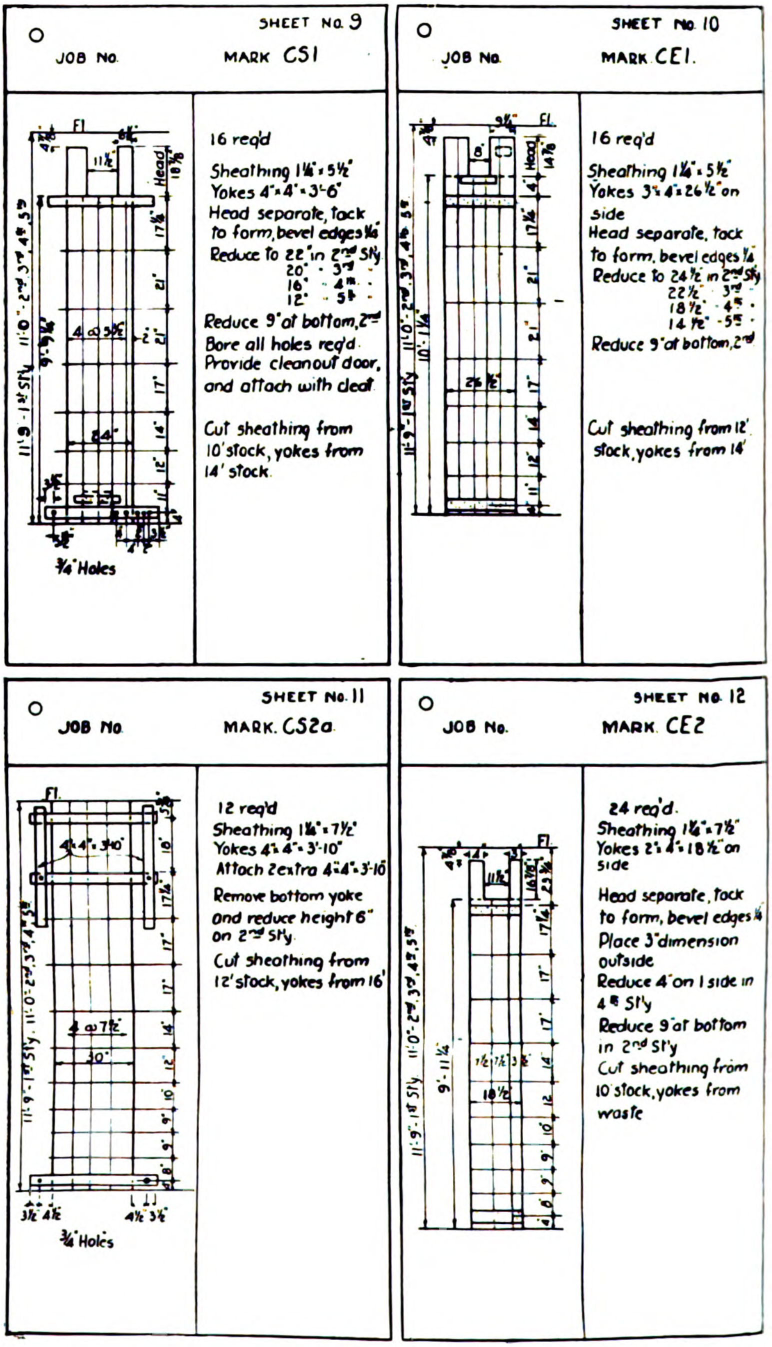
MARK LS4-5



⅞" Boards 2-5½", 1-7½", Battens 1¼" × 4"
Cleats 2" × 2" × 16", Provide 2 keys 2" × 4" × 16⅞"
Bevel Ends and opening sides ¼"
Tack cleats over openings
Openings 8" × 14⅞"

MK	SIZE	NO	REMARKS
LS4	16⅞" × 13'-7"	2	Same all Floors
5	16⅞" × 12'-9½"	2	Clearance at interior
			Col only

FIG. 218.



SHEET No. 9
JOB No.
MARK CS1

16 req'd

Sheathing 1¼" × 5½"
Yokes 4" × 4" × 3'-6"
Head separate, tack to form, bevel edges ¼"
Reduce to 22" in 2nd St'y
20" " 3rd "
16" " 4th "
12" " 5th "
Reduce 9" at bottom, 2nd
Bore all holes req'd.
Provide cleanout door, and attach with cleat.

Cut sheathing from 10' stock, yokes from 14' stock.

SHEET No. 10
JOB No.
MARK CE1.

16 req'd

Sheathing 1¼" × 5½"
Yokes 3" × 4" × 26½" on side
Head separate, tack to form, bevel edges ¼"
Reduce to 24½" in 2nd St'y
22½" " 3rd "
18½" " 4th "
14½" " 5th "
Reduce 9" at bottom, 2nd

Cut sheathing from 12' stock, yokes from 14'

SHEET No. 11
JOB No.
MARK. CS2a.

12 req'd

Sheathing 1¼" × 7½"
Yokes 4" × 4" × 3'-10"
Attach 2 extra 4" × 4" × 3'-10"
Remove bottom yoke and reduce height 6" on 2nd St'y
Cut sheathing from 12' stock, yokes from 16'

SHEET No. 12
JOB No.
MARK. CE2

24 req'd.

Sheathing 1¼" × 7½"
Yokes 2" × 4" × 18½" on side
Head separate, tack to form, bevel edges ¼
Place 3" dimension outside
Reduce 4" on 1 side in 4th St'y
Reduce 9" at bottom in 2nd St'y
Cut sheathing from 10' stock, yokes from waste

FIG. 219.

When they will not interfere with other work they can be carried directly from the bench to the building, piling in small stacks conveniently located for the erectors. Braces, wedges, ribbons, mudsills, etc., which may have to be cut but not made up are also handled by this foreman.

Erection.—All panels, timbers, etc., necessary should be delivered to the erecting carpenters as required, so that they will not have to leave their work to fetch material or wait for it.

The key plan is the foreman's guide to erection, but at the same time he must be familiar with the building plans. He should also have a set of detail sheets to show any changes necessary to the forms on upper floors.

Methods and order of erection have been mentioned in Chapter IX. The work must be planned so that each operation is kept in advance of the succeeding one. The placing of slab panels should closely follow the setting of beam sides, so that the steel workers can follow on close behind the forms.

A bench should be set up on each floor where necessary changes to the forms can be made. It is seldom economical to send panels back to the sawmill to make these changes.

The erecting foreman must look after the supply of nails, wire, bolts, clamps, etc.

Stripping.—The order of stripping the panels, as mentioned previously, depends on the system used. Cleats and keys that have to be removed before stripping should be nailed on the panels again to prevent loss.

As panels are stripped they should be cleaned and carried to a convenient place for hoisting, and distributed to their right location on the floor above or to the bench if they have to be changed or repaired.

This foreman will have charge of re-shoring, the method of which should be indicated on the key plans. On his ability to strip carefully, without damage to the forms, will depend the cost of repairing before they can be used again. Panels that are not to be used again should be cleaned, taken apart, nails removed, and the timber carried to stockpiles. Careful stripping and final dismantling of the panels can save the contractor much valuable timber.

Heat Generated During Setting by Rapid-Hardening Portland Cement.

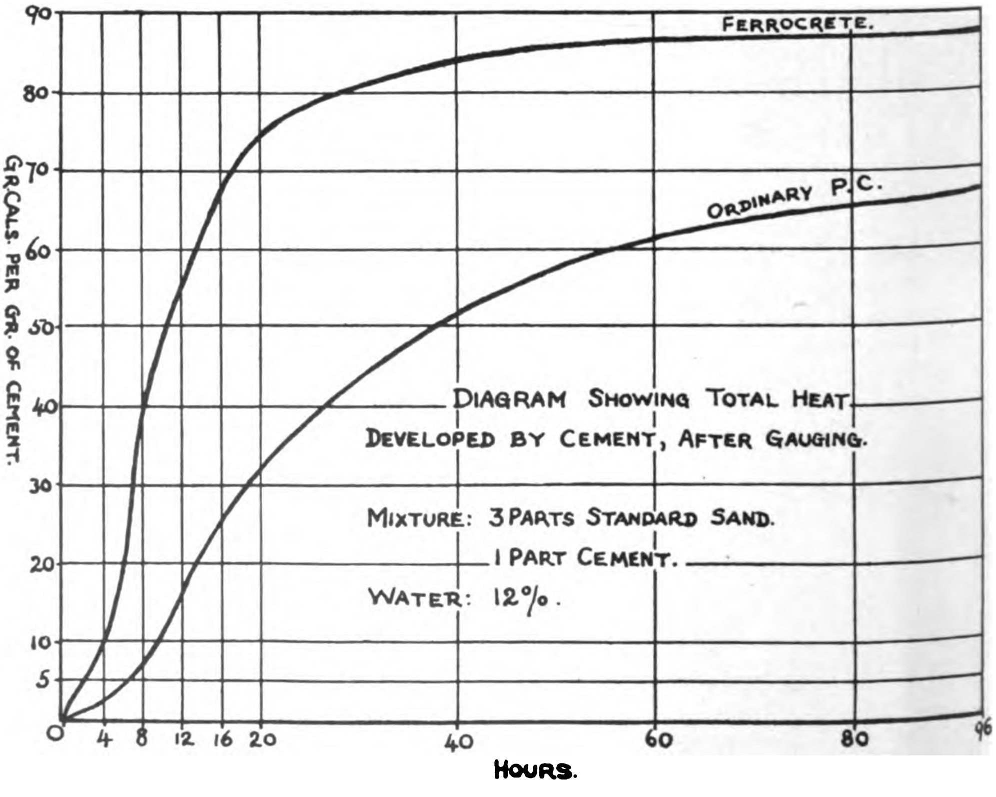
A SERIES of experiments has been carried out to ascertain how much heat is generated during the setting of " Ferrocrete " rapid-hardening Portland cement compared with ordinary Portland cement. The results are shown graphically below, and show that the rapid-hardening Portland cement has considerable advantages for winter construction and in cold climates.

In order to make a comparison a carefully-measured amount of mortar was made with each cement, using 3 parts of standard Leighton Buzzard sand to 1 part of cement. In each case the amount of water added was 12 per cent. of the weight of the sand and cement.

The mortars were gauged and immediately put into thermos flasks of 1-pint capacity. The flasks were embedded in sawdust, and a thermometer in a brass case containing mercury lowered into the mortar. The temperature of each flask was recorded at intervals of a quarter-of-an-hour for the first 8 hours, and every half-hour after that for 2 days and nights. After this readings were taken at longer periods up to four days.

From these figures the rise in temperature of the mortar as a function of time was determined. To obtain the actual heat evolved corrections were made to allow for the loss of heat by radiation from the flasks and for the heat absorbed by the rest of the apparatus.

In the diagram these corrections have been made, so that the curves show the actual amounts of heat evolved by the two cements. This is measured in gram-calories per gram of cement in the mortar.



It will be observed that after 12 hours more than three times as much heat has been evolved by the rapid-hardening Portland cement than by the ordinary Portland cement, and that after 24 hours the rapid-hardening Portland cement is still 100 per cent. above the other. At the end of four days the rapid-hardening Portland cement generated 30 per cent. more heat than the ordinary Portland cement with which it was compared.

The diagram shows that even after four days heat is still being produced by both cements.

Stresses in Reinforced Concrete Beams.

THE diagrams on pp. 334-5 are by Mr. W. T. Gedge, who writes:

"A similar diagram to this for a homogeneous beam, such as a rolled steel joist, is often given in text-books, etc., but these are of little value to show the internal stresses of a reinforced concrete beam where there are two different substances making the beam.

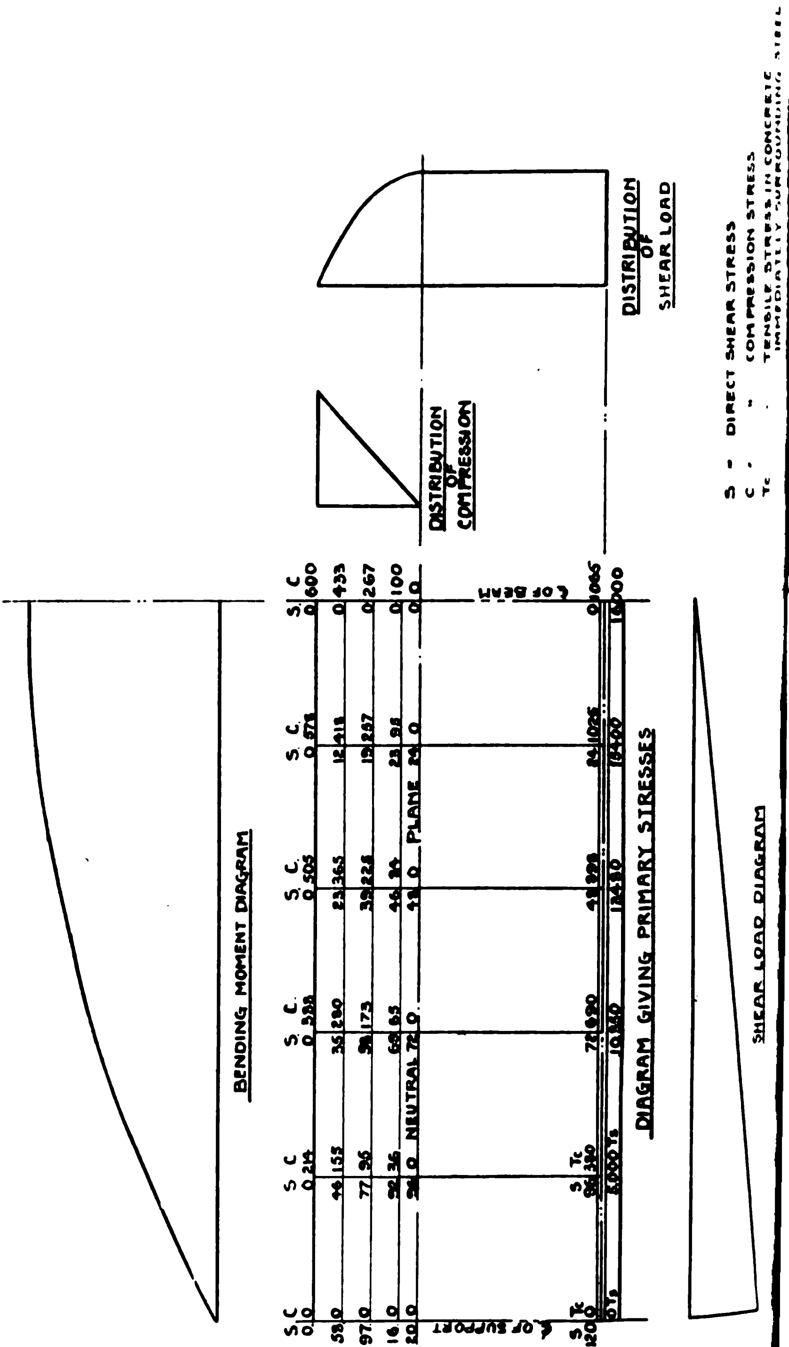
"The diagrams have been designed compatible with the maximum flexure stresses given by the London County Council Regulations, namely, 600 and 16,000 lbs. per sq. in. for the concrete and steel respectively, and give the direction and magnitude of the principal tensile and compressive stresses due to the bending and shear loads for a uniformly loaded beam of any span.

"It will be noticed that these diagrams show the necessity for, and the method of, placing shear reinforcement, or rather reinforcement necessary to provide for the inclined tension, and the necessity of regulating the dimensions of the beam to keep the inclined compression within safe limits."

[While we have pleasure in publishing these diagrams, we would point out that 1,065 lbs. per sq. in. is a much greater stress than concrete can resist in tension; it is inconsistent with the usual basis of design under which the tensile strength of concrete is ignored, and also with the curve given showing the vertical distribution of shear.—EDS.]

Recent Patent Applications.

243,727.—P. Ferrier: Reinforced concrete.
244,756.—H. S. Spackman: Hydraulic cement.
246,498.—K. Ebers: Manufacture of cement.
265,245.—J. H. Southern and R. Hill & Co., Ltd.: Reinforcement.
265,304.—L. J. B. Blake: Concrete mixers.
265,474.—G. B. Brader: Centering for concrete floors.
265,494.—G. Hertyka: Manufacture of cement.
265,752.—W. Sabatini: Reinforced concrete.
265,807.—G. W. Rawlings: Concrete buildings.
265,817.—H. F. H. Poole: Concrete ventilating brick.
265,861.—A. Wolfsholz: Concrete piles.
266,088.—H. Hallam: Concrete.
266,260.—Dr. B. Bauer: Reinforcement.
266,457.—E. J. Burge: Supporting concrete shuttering against walls.
266,814.—A. C. Knipe: Cement.
267,339.—W. Hopkins: Consolidating concrete.
267,642.—R. Illemann: Concrete pipes.



STRESSES IN REINF

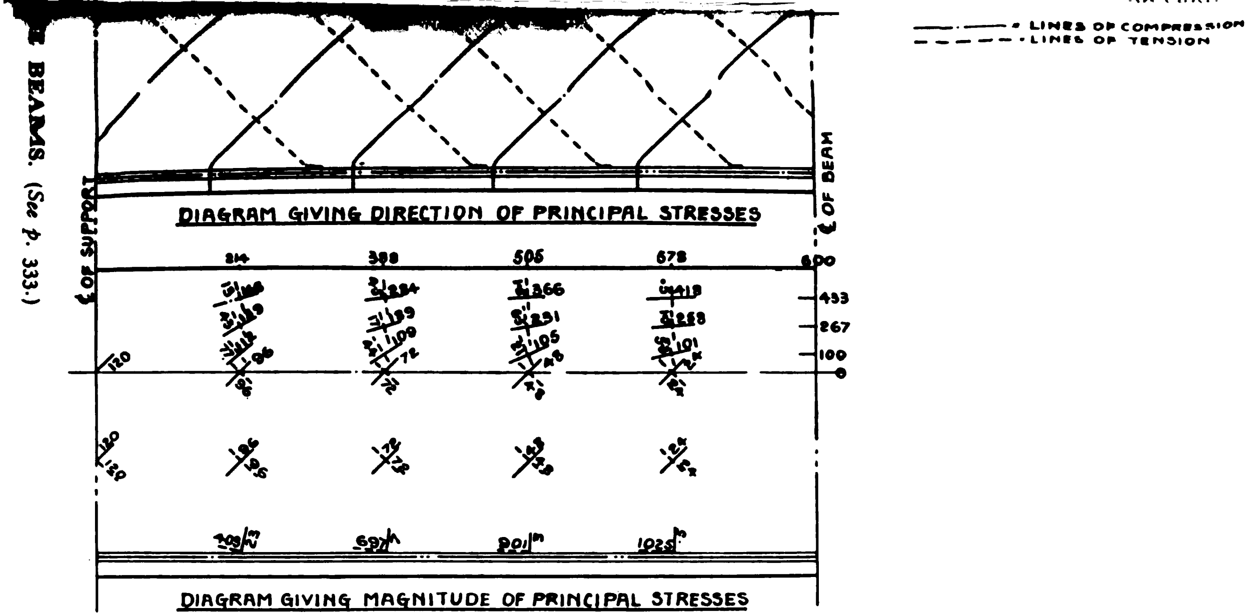

LINES OF COMPRESSION
LINES OF TENSION
DIAGRAM GIVING DIRECTION OF PRINCIPAL STRESSES
℄ OF SUPPORT
℄ OF BEAM
214
388
505
678
600
433
267
100
0
120
DIAGRAM GIVING MAGNITUDE OF PRINCIPAL STRESSES

DIAGRAM OF A REINFORCED CONCRETE BEAM LOADED UNIFORMLY OVER SPAN, GIVING DIRECTION & MAGNITUDE OF PRINCIPAL STRESSES AT VARIOUS SECTIONS OF BEAM BASED ON THE ASSUMPTIONS OF THE STRAIGHT LINE FORMULA. WHERE THE LINES ARE HORIZONTAL THE STRESS REACHES A MAXIMUM & WHERE VERTICAL A MINIMUM. THE MAXIMUM COMPRESSIVE & TENSILE STRESSES IN THE CONCRETE & STEEL ARE 600 & 16,000 LBS PER □" RESPECTIVELY WHICH GIVE A PERCENTAGE AREA OF STEEL TO THE SECTIONAL AREA OF CONCRETE, OF ·67 THE SHEAR STRESS AS BEEN LIMITED TO 120 LBS PER □"

BEAMS. (*See p.* 333.)

The Rigidity of Joints in Reinforced Concrete.

By W. S. GRAY, B.A., M.A.I. (Dublin).

FROM the point of view of design of reinforced concrete structures engineers may be divided into two main groups, (*a*) those who neglect the stiffness of the columns when calculating the moments in continuous beams, and (*b*) those who, taking account of the column stiffness, design the beams for the reduced moments resulting from this stiffness. Although the first group is in England numerically greater than the second, this is by no means the case on the Continent where much importance is assigned to the consideration of continuous structures as rigid frames. In America also the Joint Committee regulations allow designers to use a reduced bending moment in continuous beams which are monolithic with the columns.

The new German regulations specify definitely the column moments to be designed for in terms of the relative stiffnesses of the beams and columns. As is well known, Dr. Faber was the first engineer to present to English readers a ready method of calculating the column moments.

The principal argument of those in the first group mentioned in favour of their method is that a reinforced concrete structure is not a perfectly elastic system, and consequently the stresses and moment distribution deduced from the computation of such a structure as perfectly elastic are not reliable. If this argument were to be followed to its logical conclusion it would entail " scrapping " the existing regulations, to which these same designers work, specifying $\frac{wl^2}{12}$, $\frac{wl^2}{24}$, etc., for the moments in continuous beams over free supports. The coefficients in such rules are derived from the elastic theory, and in fact a continuous beam on knife-edge supports is nothing more than the limiting case of a beam monolithic with the supports when the stiffness of the columns compared with that of the beam becomes very slight.

Tests made in Germany * and in America by A. Mishi have shown that there is complete continuity of the column and beam even when, as in Dr. Probst's tests, no additional steel, beyond the straight column bars running up into the beam, was used to insure that the joint would remain rectangular and that the change of slope of the neutral axes would be equal.

Dr. Probst found that in a three-span rigid frame tested by him the continuity between beams and columns increased the resistance to primary cracking in the loaded spans by 28 per cent., and the resistance to failure, by passing the elastic limit of the steel, by 40 per cent. when compared with a similar three-span beam on knife-edge supports. The frame tested was by no means a " model " size, each span being 10 ft. and each column 10 ft. clear height. The end columns cracked first at the top on the outer faces, as was to be expected.

Mr. Mishi's experiments on a number of different shapes of frames gave conclusive evidence of the existence of tensile cracks in the outer faces of the end columns and of the continuity of the joints.

At the American Concrete Institute's Convention in 1924 Mr. F. E. Richart stated that " no very extended examination of reinforced-concrete buildings is necessary to demonstrate that the average wall-column contains a number of cracks which, from their position, are obviously produced by bending stresses. Such cracks are often unsightly; on the exterior face of the column they may affect its durability."

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* *Untersuchungen am durchlausenden Eisenbeton Konstructionen,* by Dr. Ing. Probst.

Undoubtedly the introduction of haunches at the junction of beam and column and the consequent local increase in the beam stiffness at its ends will cause the moments at the beam ends, and therefore also in the columns, to increase, and those at the middle of the beam to decrease. In such a way a practical design will differ from the ideal elastic structure which is analysed, but allowance can be made for this alteration in moment distribution by designing the beams for the moments calculated and the columns on a slightly conservative basis. In this way the structure will be safe and the beams, if anything, will be stronger than necessary.

In America tests have also been made on completed structures (the Shredded Wheat Factory, the Soo Line Freight Terminal, the Western Newspaper Union Building, etc.) and in all cases it was shown that quite large bending deformations existed in columns located at the edges and corners of the loaded areas. Fine tension cracks were observed in the columns.

It would seem that engineers have been misled in some cases by drawing a false analogy between steel and reinforced concrete structures. With the object of simplifying calculations assumptions have been made which, however correct they may be for steelwork, do not apply in reinforced concrete design.

Steel is a ductile material capable of a very large extension before fracture, and the secondary stresses which by calculation are very high (sometimes they are equal to the primary stresses) only produce a local effect. Even if they pass the elastic limit a fracture does not occur; there is only a permanent set which is not necessarily injurious. On the other hand high local stresses may produce unsightly cracks in reinforced concrete, which is not a ductile material. In water-tight constructions such cracks are, of course, fatal.

One of the foremost advocates of taking the column stiffness into account is Professor G. Magnel, of Ghent, who was formerly engaged with one of the principal designing and contracting firms in London. He has recently issued the second part of his course on reinforced concrete * in which he expounds his method of calculating the moments in columns and beams of rigid frames and gives influence lines for moving loads on such structures. From these curves one may calculate in a few minutes the maximum moments due to any system of loading, whether fixed or in motion. One need not assume that the column rigidity is nil when using this book. The methods of Professor Magnel are sufficiently quick to be used in the ordinary drawing-office. In fact the writer has used the older edition of this book for some years and found it extremely useful when designing crane gantries, continuous span bridges, etc.

In Professor Magnel's method the horizontal deflection of an unsymmetrical or unsymmetrically-loaded frame is neglected. This is a reasonable assumption, as the sides of slabs are often restrained, and in any case the slabs may be regarded as very deep girders, in a horizontal plane, with very small deflections. The neglect of this deflection is of little consequence. In 1922 the writer gave the results of calculations on the moments in a three-span rigid frame under unsym-

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* *Pratique du Calcul du Béton Armé*, G. Magnel (Van Rysselberghe & Rombaut, Gand).

metrical loading * and horizontal deflection and his results differed but little from Professor Magnel's, which neglect the deflection, although the amount of work involved in deducing them was much greater.

New matter concerning slabs supported on all four sides and continuous slabs has been added and comparisons are made between the results given by Dr. Lewe in *Pilzdecken* and by M. Mesnager.

The book is accompanied by a large number of useful diagrams.

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* Australasian Association for the Advancement of Science, 1922 Meeting at Wellington, N.Z.

Questions and Answers relating to Reinforced Concrete.

Readers are cordially invited to send in questions relating to concrete. These questions will be replied to by an expert, and, as far as possible, answered at once direct and subsequently published where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—ED.

Reinforcement of Tank.

QUESTION.—I should be obliged if you would clear up the following difficulties to me:

In "The Concrete Year Book, 1926," Chapter 5, dealing with water towers, reference is made to reinforcement as follows: "The reinforcement should be disposed as symmetrical as possible and in such a manner as not to neglect the stresses due to shrinkage and temperature variation. A factor not to be neglected is the stresses in a structure of this kind when one side is exposed to the direct action of the sun and the other side is kept cool."

What means are adopted in practice to provide for

(*a*) The stresses due to shrinkage and temperature variation,

(*b*) The action of the sun's rays in heating one part and leaving cool another part.

What is the minimum diameter of tank, where allowances for such stresses need not be made?

On page 70 of the same book the American specification deals with water-tight joints, and states: "Vertical joints shall be made by a metal water-stop." What is a metal water-stop? Is the joint obtainable on the market?

Malta. L. GATE.

ANSWER.—Stresses due to shrinkage can be reduced to a minimum by avoiding too wet a mixture of concrete and employing a high percentage of steel in both directions on both faces, whether this steel is required to resist stresses due to water pressure or not. Steel stresses due to water pressure should be kept low, certainly not above 8,000 lbs. per sq. in. The steel should be in the form of small rods at close centres rather than large rods far apart. Stresses due to unequal heating or cooling, as, for example, those due to the sun's rays on one side of a tank, are kept to a minimum by making the walls thin so that with a definite temperature gradient the difference in temperature from the outside to the inside will be small. This consideration also leads to a thin wall amply reinforced in preference to a thick wall with less reinforcement. There is no minimum diameter below which these considerations do not apply, but a small tank would naturally be thinner and therefore less subject to temperature stresses.

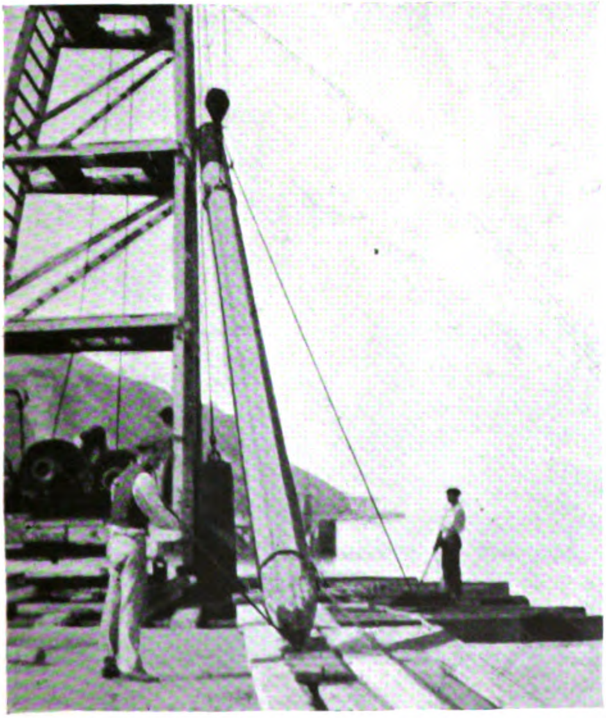
The metal water-stop referred to in the American specification probably relates to a piece of copper sheet, half of which is embedded in the first portion concreted on one side of the vertical joint, and the second half of which would be embedded in the second portion on the other side. So far as we know there is no special material on the market superior to the plain commercial article for this purpose.
—O. F.

Reinforced Concrete Jetty in Portugal.

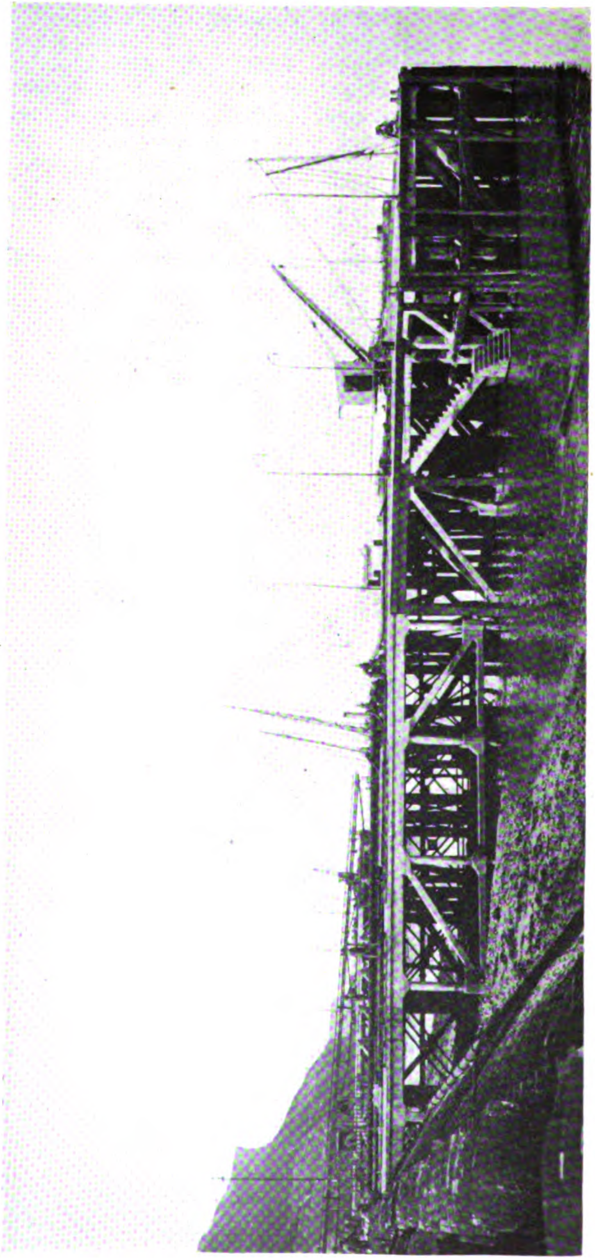
THE reinforced concrete jetty described was constructed recently by the Lisbon Coal and Oil Fuel Co., Ltd., at Banatica, on the Tagus opposite Lisbon. This Company possesses an installation for storing and handling of petroleum alongside the river. A few years ago a reinforced concrete jetty was constructed on cylinders and reinforced concrete piles, but owing to the development of the business it was found necessary to construct a new jetty, or rather to reconstruct an existing composite timber and concrete jetty which was falling into disrepair. The considerable amount of current which exists at this part of the Tagus, and the fact that the beach suddenly shelves down to a very great depth, presented considerable difficulties in the construction of the work, which was carried out departmentally under skilled supervision.

The design of the reinforced concrete work was entrusted to Messrs. Edmond Coignet, Ltd., of London, who had already designed an extensive jetty on the Thames for an associated company several years ago. The illustrations which we reproduce show the completed work, and the jetty in course of construction. The total length of the jetty is 142 ft. and the pier head is about 80 ft. by a width of 33 ft. Only half of the approach was constructed in reinforced concrete, the remaining half being a composite structure of timber and concrete which formed part of the original jetty approach.

Owing to the considerable depth of water in front of the pier head some of the piles, which are 15 in. octagonal, had to be no less than about 60 ft. in length, and heavily reinforced on account of the difficulty in handling and the heavy loads coming upon them. Piles were driven by means of an ordinary drop-monkey weighing three tons, and a steam winch. This plant was supplied by the British Steel Piling Co. of London. The structure



Pile Driving.



Reinforced Concrete Jetty in Portugal. *(See p. 339.)*

Reinforced Concrete Jetty in Portugal.

is strongly braced together by means of horizontal and diagonal braces, all of these members being pre-cast. After the piles were driven the concrete around the bars was stripped, leaving the core intact, and the bars of the braces were bent round the vertical bars of the piles, after which the joint was encased in concrete.

One of the photographs shows the size of the oil tank ships which the jetty has to accommodate. The whole of the reinforced concrete work has been thoroughly protected against damage from ships or barges by means of heavy fenders.

Aluminous cement was used for the construction of the piles, and very good results were obtained by this method. The whole of the work was carried out by local labour, with the exception of the supervising engineer. In spite of this difficulty, however, the work was satisfactorily carried out.

"Empire Municipal Directory."—This Directory furnishes lists of all the corporations, county, urban and rural district councils in Great Britain and Ireland, with the names of their officials, whilst those of the most important foreign and colonial countries are also given. In addition to the Directory, the volume constitutes an encyclopædia and handbook of reference on practically all aspects of municipal activities and enterprise, for it contains articles on a variety of subjects, including roads and road-making, sewerage and sewage disposal, concrete and concrete construction, statutes passed and departmental orders issued during 1926, notes on legal decisions affecting local authorities, housing and town planning, Government departments and their officials, etc. The 1927 volume has just been published at 10*s.* 6*d.*

Mild versus High Tensile Steel.

Some interesting correspondence has passed between the Ministry of Transport and the Weston Concrete Engineering Co., Ltd., on the question of the relative value of mild steel and high tensile steel, particularly in relation to concrete road construction.

The correspondence arose out of a clause in the Ministry's specification for special trunk road contracts, as follows:

> "Steel reinforcement may be either of rolled steel with a yield point of not less than 32,000 lbs. per sq. inch, or high tensile steel with a yield point of not less than 72,000 lbs. per sq. inch.
>
> "The working stress in the case of the former shall not exceed one half of the above minimum yield point, and in the case of the latter it shall not exceed one third.
>
> "The type and form of reinforcement shall be selected by the engineer, but for guidance the following information is given.
>
> "The weight of a single layer of rolled steel reinforcement should not be less than 7 lbs. per super yard, and where double reinforcement is used the weight of the top and bottom layers should not be less than 14 lbs. per super yard.
>
> "The comparative equivalent weights of rolled high tensile steel on the above-mentioned basis would be found as follows:
>
> 10 lbs. per sq. yd. minimum yield point 32,000 lbs. per sq. in. Equivalent high tensile steel with a minimum yield point of 72,000 lbs. per sq. in. should have a weight of

$$10 \times \frac{\frac{1}{2} \times 32{,}000}{\frac{1}{3} \times 72{,}000} = 6\tfrac{2}{3} \text{ lbs. per sq. yd."}$$

In the course of the correspondence it was urged by the Company that there was no valid reason for the preference shown by the Ministry in favour of high tensile steel, and these arguments were strengthened by reports from Messrs. David Kirkaldy & Son, Dr. Oscar Faber, O.B.E., D.Sc., Messrs. Considère Constructions, Ltd., and Mr. G. Topham Forrest, Architect to the London County Council.

In the course of their report Messrs. Kirkaldy stated:

"The essential requirement in road slabs, and in all concrete structures where cracks cannot be permitted, is a concrete of high tensile strength. It follows also that the usual light steel mesh put into road slabs is not there for imparting strength to the slab, as most road engineers will readily admit. Further, the grade of steel is quite immaterial so far as the usual life of a road slab is concerned, for the concrete cracks long before the elastic limit of the softest steel is reached. A high tensile steel only begins to be of greater service than a mild steel when a structure has become cracked.

"Actual tests of similar slabs show that the bending moment at which the first crack appears is independent of the grade of the steel mesh. The ultimate strength of the slab is not independent of the grade of the steel, but the conditions under which such strength is developed are not likely to occur in a decent roadway."

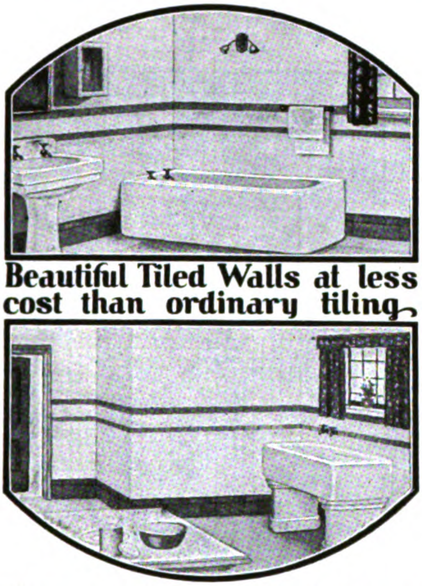
Dr. Faber, in his report, stated that the subject was one that he had studied very closely and had had ample opportunity of collecting all the facts which appeared to bear on the question.

"I am," he said, "aware that the Ministry of Transport allows 6⅔ lbs. of drawn steel wire as equivalent to 10 lbs. of mild steel rod as road reinforcement. In my view this is entirely fallacious, and I would not myself be willing on work for which I was responsible to allow any reduction in the weight of steel used as road reinforcement by reason of the substitution of drawn wire instead of mild steel rod. I have, in fact, constructed several roads which are standing up against the heavy traffic very excellently, and in these mild steel reinforcement has always been used.

"The reasons why I should not allow a reduction in the weight of steel if drawn wire is substituted, are the following:

"(1) The object of introducing steel into roads is principally: (*a*) to obviate cracks due to shrinkage, (*b*) to obviate cracks due to overstressing produced by bending of the slab under the point load of the traffic.

"(2) The amount of reinforcement used in roads as commonly designed in the Ministry of Transport's schemes is so small that the moment of resistance of the slabs after they have cracked,



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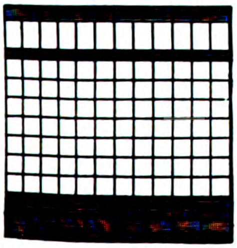

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The 14th *Feather from the* Pelican
Plucked by W. Heath Robinson.

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G. & T. EARLE (1925) LTD
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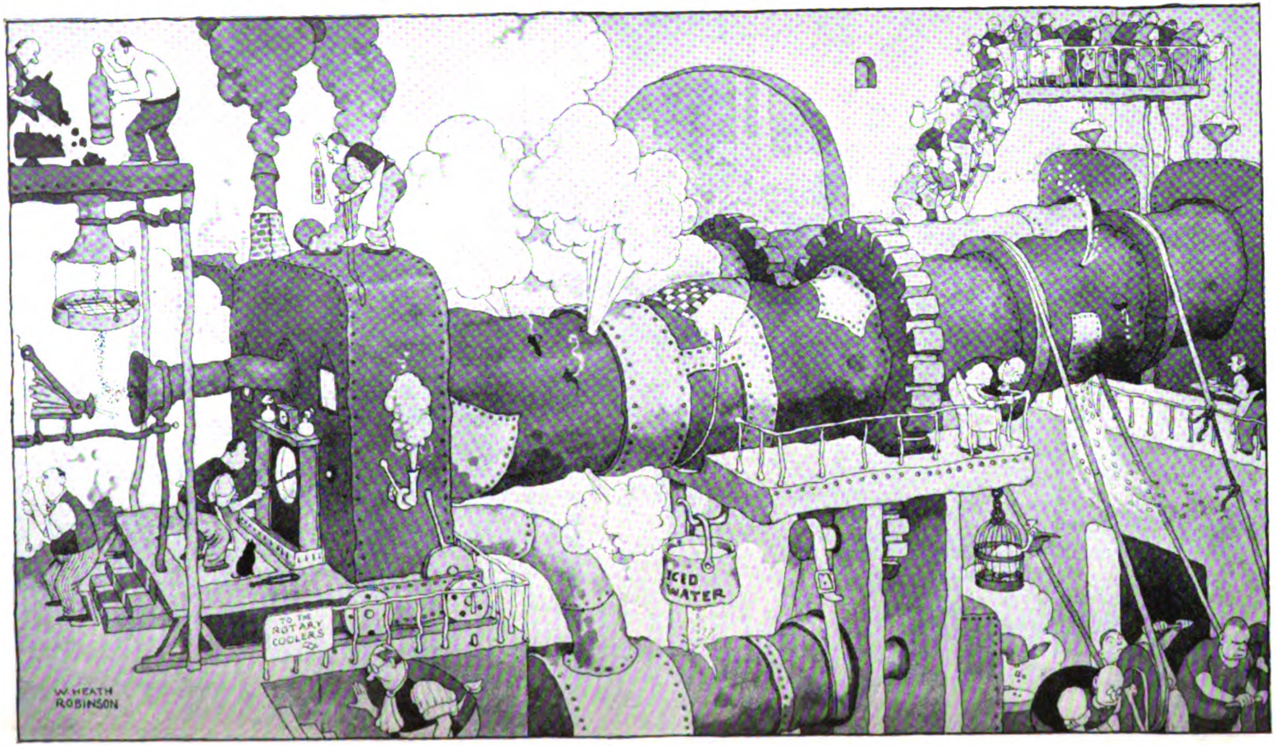

THE ROTARY KILNS—3. These kilns are long rotary cylinders set on an incline, through which the slurry passes and is calcined. Coal for firing the kiln is first ground and then blown into the kiln in the form of a torch, while the slurry is inserted at the other end, from where it gradually flows down the kiln. The slurry thus meets the hot air from the ground coal, and finally passes through the flame. It leaves the kiln as clinker and drops into cylindrical coolers below, and, after cooling, it is conveyed to the stores.

when the steel takes the whole of the tension and the concrete the whole of the compression, is not appreciably greater, and is sometimes less, than the moment of resistance of the slabs before cracking when the concrete resists the tension.

"You submitted to me a report from Messrs. David Kirkaldy & Son showing that an 8-in. slab containing a single wire mesh of an effective area of 0·14 sq. in. per ft. width of slab placed at a distance of 1½ in. from the tension face of the slab would have a moment of resistance of 25,600 lbs. before cracking, assuming that the concrete takes the whole of the tension at a stress not exceeding 200 lbs. per sq. in., but the effect of the reinforcement is to increase this to 26,620 in. lbs., and that after cracking this moment would produce a tensile stress of 31,400 lbs. per sq. in. in the steel and 440 lbs. per sq. in. in the concrete.

"These figures I agree with, and they seem to me to show conclusively that as the reinforced slab after cracking is no stronger than the plain concrete slab before cracking, the object of the reinforcement cannot be to increase the moment of resistance of the slabs, because it will be seen that it does not achieve this object, and if this is desired or acquired it is necessary to use a considerably greater percentage of steel. As, however, in ordinary road practice this is not done one cannot escape the conclusion that the steel is not introduced with the principal object of increasing the moment of resistance.

"(3) When, however, the action of steel as preventing cracks due to shrinkage of the concrete is considered, experience shows that the effectiveness of the steel for this purpose depends on two things: (*a*) the percentage of steel used, (*b*) the bond or adhesion between the steel and the concrete.

"When a crack in a concrete slab occurs, having some definite width, for example, $\frac{1}{16}$th in., an examination of the steel at this point does not indicate that the steel has drawn out into a neck sufficient to give this elongation locally without slipping in the concrete at either side.

"What actually happens is that the steel slips in the concrete for some considerable distance on either side of the crack and the width of the crack really represents the extension in the steel in the length which has slipped. It is further found that cracks below a certain thickness do not appear to permit the introduction of air and water to the reinforcement so as to produce corrosion, but that when a definite thickness of crack has been existing such corrosion is set up and ultimately destroys the slab in the neighbourhood of the reinforcement by a splitting action following the increase in size of the steel when it rusts.

"It is, therefore, of the greatest importance to keep cracks as few and as small as possible, and this is undoubtedly effected far better by commercial mild steel rods of full section than by drawn wire reinforcement of a small section, both by reason of the increased surface area of the mild steel rod and by reason of its relatively rough surface as compared with the smooth drawn surface of the wire which from this point is the worst possible surface which could be provided.

"From the point of view of the prevention of cracks there can, I think, be no question that a rough surface and a large surface area are important considerations, and these are provided by mild steel far better than by drawn wire.

"To my mind, structures like reinforced concrete roads must be protected against the corrosion of the reinforcement if the reinforcement is not ultimately to be a detriment rather than an advantage, because once corrosion is allowed to start the destruction of the concrete round the reinforcement follows. To my mind this protection of the reinforcement from corrosion requires that cracks in the concrete shall be reduced both in thickness and in number to an absolute minimum, and I am satisfied that this is best done by providing the maximum possible bond between the steel and the concrete by using commercial rods in a large area with a rough surface.

"(4) Even taking the point of view of those who base their arguments entirely on the fact that a drawn wire has a higher tensile strength and perhaps a higher yield point than a mild steel rod, even if the latter has a somewhat greater sectional area, it follows at once that this higher stress cannot be brought into play without providing greater elongation per foot run, and therefore more cracks and wider cracks. When it is remembered how much more readily the bond is broken with drawn wire even at the same stress as mild steel it will be clear how much greater the tendency will be to produce cracks with the wire which ultimately allows corrosion to be set up.

" (5) If there were any real advantage in using high tensile steel in reinforced concrete these advantages would be far greater in the case of internal structures, such as beams supporting floors in a building where the problem of corrosion is less serious, yet even here the best practice prohibits its use. No official regulations in England permit of its adoption with higher stresses, and in the countries like France where reinforced concrete has made even more headway than in England, and where the reinforced concrete engineers have not been backward either as pioneers of reinforced concrete nor in its latest developments, the steel used is one having a considerably lower tensile strength than the British Standard Specification for mild steel, and the stresses used by them are also lower.

" Put in a nutshell it almost comes to this: That high stresses and smooth surface make for bad cracking in reinforced concrete; bad cracking shortens the life of reinforced concrete and is to be avoided at all costs."

Messrs. Considère Constructions, Limited, stated, in part:

" The use of high stresses consequent on the employment of high tension steel is open to many technical objections, and to many practical objections also. The chief of the former is due to the fact that, since the modulus of elasticity of both qualities of steel is the same, identical unit stresses produce identical elongations. With both mild steel and high tension steel, this phenomenon continues far beyond the point at which the concrete surrounding the reinforcement cracks. Therefore, the fact that the high tension steel has a higher yield point may be of use in other branches of engineering, but it is of no interest at all to designers of reinforced concrete, since the practical limitation of working stress is dependent on the point at which the concrete cracks. Therefore, whatever working stress is allowed on reinforcement of mild steel, the same and no more should be allowed on reinforcement of high tension steel."

The correspondence was concluded by the following letter from the Ministry:

" The opinions expressed in the reports have been carefully considered, and it is agreed that a higher percentage of steel than at present used in reinforced concrete roads would be greatly desirable.

" Having regard, however, to the present practice in this respect, the Minister does not propose to make any change in the clause in the specification for trunk road schemes relating to road reinforcement."

DATA FOR PRICING REINFORCED CONCRETE.*

MATERIALS DELIVERED 4 MILES FROM CHARING CROSS.

		s.	d.
Best Washed Sand	per yard	16	0
Clean Shingle, ¾ in. mesh	,,	14	0
,, ,, ⅜ in. mesh	,,	15	6
Thames ballast	,,	10	6
Broken brick (¾ in.)	,,	11	6
Best British Portland Cement (delivered London area)	per ton 58s. to	63	6
Rapid-Hardening Portland Cement	delivered London 10s. per ton extra		
"Super-Cement"	per ton 88s. to	93	0
"Lightning" Brand Aluminous Cement	,, 100s. to	105	6
Ciment Fondu	works f.o.r.	95	0

Boarding for Shuttering—

		Sawn. s.	*Sawn.* d.	*Wrot.* s.	*Wrot.* d.
1 in.	per square	23	6	27	6
1¼ in.	,,	29	6	33	6
1½ in.	,,	35	6	41	0

Sawn Timber for Struts and Supports—

3 in. by 4 in.	from £22 per standard
3 in. by 6 in. and 3 in. by 7 in.	,, £20 ,, ,,

Mild Steel Rods for Reinforcement—

		s.	d.
⅝ in. to 2⅞ in. Rounds	per cwt.	10	6
7/16 in. to ½ in. Rounds	,,	10	9
⅜ in. Rounds	,,	11	0
¼ in. Rounds	,,	12	0

Breeze Slabs per yd. super: 2 in., 1/11; 2½ in., 2/4; 3 in., 2/9; 4 in., 3/6.

MATERIAL AND LABOUR, INCLUDING 10 PER CENT. PROFIT.

(*Based on Contracts up to £2,000.*)

Portland Cement Concrete well mixed in proportion 1 : 2 : 4—

				s.	d.
Do.	do.	in foundation	per foot cube	1	11
Do.	do.	in columns	,, ,,	2	1
Do.	do.	in beams	,, ,,	2	3
Do.	do.	in floor slabs 4 in. thick	per yard super	6	0
Do.	do.	in floor slabs 5 in. thick	,, ,,	7	6
Do.	do.	in floor slabs 6 in. thick	,, ,,	9	0
Do.	do.	in floor slabs 7 in. thick	,, ,,	10	6
Do.	do.	in walls 6 in. thick	,, ,,	8	8

(*Add for hoisting* 3s. 6d. *per yard cube above ground-floor level. Add for "Ferrocrete"* 1s. 10d. *per yard cube.*)

Steel Reinforcement, including Cutting, Bending and putting into Position and securing with Stout Binding Wire—

		s.	d.
From ¼ in. to ⅜ in.	per cwt.	22	6
,, 7/16 in. to ½ in.	,,	21	6
,, ⅝ in. to 2⅞ in.	,,	20	6

EXTRA LABOUR TO BENDS in ¼-in. rods, ½d.; ⅜-in. rods, 1d.; ½-in. rods, 1¼d.; ⅝-in. rods, 1½d.; ¾-in. rods, 1¾d.; ⅞-in. rods, 2d.; 1-in. rods, 2¼d.; 1⅛-in. rods, 3d.; 1¼-in. rods, 3½d.; 1⅜-in. rods, 4½d.; 1½-in. rods, 6d. (per bend per cwt.).

EXTRA LABOUR TO HOOK BENDS: ¼ in., 1d.; ⅜ in., 2d.; ½ in., 2½d.; ⅝ in., 3d.; ¾ in., 3½d.; ⅞ in., 4d.; 1 in., 4½d.; 1⅛ in., 6d.; 1¼ in., 7d. (per bend per cwt.).

Shuttering—

		s.	d.
Shuttering and Supports for Concrete Walls (both sides measured)	per square	59	0
Centering to Soffits of Reinforced Concrete Floors and Strutting, average 10 ft. high	per square	55	0
Do. do. in small quantities	per ft. super	0	10
Shuttering and Supports to Stanchions for easy removal, average 18 in. by 18 in.	per ft. super	0	11½
Do. do. as last, in narrow widths	,, ,,	1	1½
Do. do. to sides and soffits of beams, average 9 in. by 12 in.	,, ,,	1	1½
Do. do. as last, in narrow widths	,, ,,	1	3½
Raking, cutting, and waste to shuttering	per ft. run	0	3
Labour, splay on ditto	,, ,,	0	2
Small angle fillets fixed to internal angles of shuttering to form chamfer	,, ,,	0	3

WAGES.—The rates of wages on which the above prices are based are:—Carpenters and joiners, 1/9½ per hour; Carpenters working on old shuttering, 1/10½; Labourers on building works, 1/4½; Men on mixers and hoists, 1/5½; Bar-benders, 1/5½.

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Prospective New Concrete Work.

ABERDEEN.—*Road.*—The Corporation Streets and Roads Committee has decided to extend Anderson Drive southwards from Great Western Road to the Bridge of Dee. The cost is estimated at £17,180.

BALLYMENA.—*Houses.*—The R.D.C. proposes to build 193 houses in the rural area. The cost is estimated at £64,500.

BARNSTAPLE.—*Houses.*—The T.C. has instructed the Surveyor to prepare plans for the erection of 22 houses at Mill Road and Pottingdon Road.

BEXLEY.—*Concrete Bungalows.*—The U.D.C. has applied for sanction to borrow £30,500 for the erection of 50 concrete bungalows on the " Nash " system.

BEDWORTH.—*Houses.*—The Foleshill R.D.C. has prepared schemes for the erection of 730 houses in the parishes of Bedworth, Stoke, Stoke Heath, Wyken, Bingley, Walsgrave, Exhall, Foleshill, Withybrook, and Willenhall.

BIDDULPH.—*Houses.*—The U.D.C. has decided to build 50 houses in Station Road.

BOURNEMOUTH.—*Defence Works.*—The T.C. has applied for sanction to borrow £10,000 for the extension of the sea wall and promenade on the west of Fisherman's Walk.

BRAINTREE.—*Houses.*—The U.D.C. has instructed the architect to prepare plans for the construction of 56 houses on the Cressing Road site.

BRAMLEY.—*Houses.*—The Rotherham R.D.C. is to erect 22 houses in Bramley.

CANVEY ISLAND.—*Concrete Road.*—The Council proposes to construct a reinforced concrete road across the island. The cost is estimated at £50,000.

CHESTER.—*Houses.*—The Corporation Housing Committee recommends the Council to apply for permission to borrow money for the purchase of a site in Holls Lane.

CHORLEY.—*Houses.*—The Housing Committee recommends the T.C. to build 20 houses on land adjoining the Rangletts site.

CHORLTON.—*Houses.*—The Town Planning Special Committee recommends the Manchester T.C. to approve of the construction of 100 houses in Buckingham Road, Chorlton.

CHRISHALL, ESSEX.—*Retaining Wall.*—A retaining wall, estimated to cost £3,024, is to be constructed at Chrishall.

CORRINGHAM.—*Road.*—The Orsett R.D.C. has given instructions for the preparation of plans for constructing a road through Corringham to link up Thames Haven Road with Lampitts Hill.

CROYDON.—*Houses.*—The Council is recommended to purchase sites on which to erect 352 houses.

DALTON.—*Houses.*—The Rotherham R.D.C. proposes to build 40 houses at Dalton and 20 at Bramley.

DAVYHULME.—*Jetty.*—The Manchester T.C. is recommended to spend £6,000 on the construction of a jetty.

DEEPCAR.—*Houses.*—The Stocksbridge U.D.C. has decided to erect 20 houses at Deepcar.

DUBLIN.—*Bridge.*—The Dublin Port & Docks Board recommends the construction of a bridge to connect the Midland Great Western Railway Co.'s goods depot with the junction of Sir John Rogerson's Quay.

DUKINFIELD.—*Houses.*—The T.C. is seeking permission to build 105 houses on the Clarendon site.

EPSOM.—*Houses.*—The R.D.C. is seeking permission to build 256 houses in the rural area.

EXETER.—*Houses.*—The Corporation proposes to spend £50,125 on the construction of houses in connection with the slum-clearance scheme.

FORRES.—*Houses.*—The T.C. has decided to erect 30 houses.

GUISELEY.—*Houses.*—The U.D.C. has applied for sanction to borrow £3,000 for the purchase of a housing site.

KINGSTON.—*Houses.*—The T.C. proposes to erect 58 houses, at a cost of £28,420.

LEWISHAM (LONDON).—*Water Tower.*—A sum of £2,050 is to be spent on the construction of a water tower at the hospital.

LEYLAND.—*Houses.*—The U.D.C. proposes to build 60 houses in the Sandy Lane and Seven Stars districts.

LONG EATON.—*Houses.*—The U.D.C. is considering a scheme for the erection of 38 houses in College Street.

NELSON.—*Houses.*—The T.C. has applied for sanction to borrow £25,000 for the erection of 50 houses.

NEWCASTLE (IRELAND).—*Road.*—The U.D.C. proposes to construct a road from Dundrum Corner to South Bryansford Road. The cost is estimated at £8,800.

NOTTINGHAM.—*Bridge.*—The T.C. proposes to spend £22,000 on the construction of a bridge over the canal at Woollaton Road.

PELSTEAD. — *Bridge.* — The Cosford R.D.C. proposes to spend £120 on the construction of a bridge at Pelstead.

PORTHCAWL.—*Promenade.*—A scheme is being considered for the construction of a concrete promenade at Porthcawl. The promenade will be a mile and a half in length and 100 ft. wide.

ROWLEY REGIS.—*Houses.*—The U.D.C. has applied for sanction to erect 114 houses on the Tividale Hall estate.

SHEFFIELD.—*Houses.*—The Corporation is recommended to apply for permission to erect 158 houses on the Longley estate.

SHEPTON MALLET.—*Houses.*—Application has been made for permission to borrow £10,965 for the erection of 20 houses.

SHERBURN. — *Houses.* — The Durham R.D.C. has appointed a committee to report on a site for 50 houses at Sherburn.

SHIMPLING. — *Bridge.* — The Melford R.D.C. is considering a scheme to erect a bridge over the stream near Shimpling Church.

SLOUGH.—*Houses.*—The U.D.C. has decided to build 150 houses.

STEART.—*Sea Wall.*—The Bridgwater R.D.C. and the Williton R.D.C. are considering a proposal for the provision of a sea wall at Wall Common, Steart.

STONE.—*Footbridge.*—The L.M.S.Railway Co. is considering a scheme for the provision of a footbridge over the Meaford level crossing.

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CONCRETE
MOULD
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FUNCTIONS BEST

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REQUIRED for India young Engineer for Stone and Reinforced Concrete Department—must be an A.M.I.C.E. and have had practical experience reinforced concrete town drainage, bridge work and modern roadmaking. Salary to commence Rs. 750 monthly rising to Rs. 850; three years agreement. Apply stating age and full particulars to Box K.B., 95, Bishopsgate, E.C. 2.

SUTTON.—*Houses.*—The U.D.C. proposes to build 34 houses between Sutton Common Road and Burleigh Road.

TALYBONT.—*Road.*—A scheme for the construction of a road from Talybont to Ponsticill is being considered by the Main Road & Bridges Sub-committee of the Breconshire C.C.

WOOLWICH (LONDON). — *Concrete Houses.*—Application has been made to the L.C.C. for a loan of £65,730 for the construction of 500 concrete houses at Eltham.

Tenders Accepted.

ANNAN (CUMBERLAND).—*Concrete Cottages.*—The T.C. has accepted a tender, at £8,682, for the construction of 24 concrete cottages.

GLASGOW.—*Concrete Houses.*—The Corporation has accepted the tender of Messrs. MacTaggart & Mickel, Ltd., Glasgow, for the construction of 1,000 concrete houses on the " Winget " system.

GLOUCESTER.—*Concrete Houses.*—The T.C. has accepted the tender of the Monolithic Building Co., Ltd., for the construction of 150 concrete houses.

GUILDFORD.—*Reservoirs, etc.*—The Corporation has accepted the tender of Messrs. Holloway Bros. (London), Ltd., at £15,715, for the construction of a 1,000,000-gallon service reservoir on Pewley Hill, a 500,000-gallon service reservoir on the Hog's Back, and a 6-in.

cast-iron pipe line about a mile long on the Hog's Back. Other tenders submitted: A. Streeter & Co., Ltd., £15,050; Industrial Constructions, Ltd., £15,357; Edwards Construction Co., Ltd., £15,883; H. Middleton, £15,882; Playfair Toole, Ltd., £16,602; F. Bevis, Ltd., £17,089; Johnson's Reinforced Concrete Engineering Co., Ltd., £22,750.

HACKNEY (LONDON). — *Piling.* — The B.C. has recommended for acceptance the tender of Messrs. W. & C. French for reinforced concrete piling work at the Power House.

LINLITHGOW. — *Concrete Tank.* — The Bathgate District Committee has accepted the tender of Mr. F. Flaherty, Weir Street, Falkirk, at £16,925, for the construction of a 1,000,000-gallon concrete tank at Pate's Hill.

NEW MALDEN.—*Concrete Road.*—The Maldens & Coombe U.D.C. has accepted the tender of Messrs. E. J. Harris, Ltd., at £2,776, for the construction of Thorne Road in reinforced concrete, together with paving footpaths with artificial stone. Other tenders submitted: F. Jackson, £2,811; G. Wimpey & Co., Ltd., £2,890; Durnford Construction Co., Ltd., £2,918; J. Mowlem & Co., Ltd., £2,967; Walker Weston Co., Ltd., £3,105; W. D. Harding, Ltd., £3,290; F. Bracey, Ltd., £3,386; Improved Wood Paving Co., £3,765.

ROTHERHAM.—*Bridge.*—The T.C. has accepted the tender of the Yorkshire Hennebique Contracting Co., Ltd., at £58,600, for the construction of the new Chantry Bridge.

SOUTH MOLTON.—*Bridge and Culvert.*—The R.D.C. has accepted the tender of Messrs. Fothergill Bros., Exeter, at £1,913, for the construction of a reinforced concrete bridge and culvert at Bradford Mill, Witheredge. Other tenders submitted: G. Wimpey & Co., Ltd., £3,135; Purdie, Lumsden & Co., £2,839 13*s.*; H. Middleton, £2,831 10*s.* 3*d.*; R. T. Hortop & Co., £2,588 14*s.* 6*d.*; P. Wilson & Co., £2,180; G. Pollard & Co., Ltd., £2,116 19*s.* 4*d.*; E. Hutchings, £2,087 13*s.*; Bridge & Engineering Co., £2,000.

WINCHESTER.—*Houses.*—The Corporation has accepted the tender of the Monolithic Building Co., Ltd., at £16,548, for the construction of 42 houses at St. Giles Hill.

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CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XXII. No. 6. LONDON, JUNE, 1927.

EDITORIAL NOTES.

Reinforced Concrete Cooling Towers.

ELSEWHERE in this number we give an abstract of a paper by Mr. T. J. Gueritte discussing the advantages of reinforced concrete cooling towers from the point of view of efficiency. So far reinforced concrete cooling towers have not been built in great numbers. It is anticipated, however, that the efficiency and economy of the design which originated in Holland and has been adopted at Liverpool, Leicester, and elsewhere, will give a great impetus to this type of construction. Figures of initial cost are therefore of considerable importance. We are unable to give definite figures of tenders for these structures in different materials, but an analysis of the figures of competitive tenders shows that for cooling towers of equal capacity in reinforced concrete, wood, and steel, reinforced concrete is by far the cheapest material. Next comes the wood structure, costing about 30 per cent. more than reinforced concrete, while a steel structure costs exactly double as much as the reinforced concrete cooling tower. When one remembers the saving in maintenance and the longer life of the reinforced concrete structure, together with the extra efficiency detailed by Mr. Gueritte, it seems that it is only a matter of time for concrete to be the recognised material for still another type of structure.

Appointments from Universities.

ON the completion of twenty-five years' existence, the Cambridge University Appointments Board has issued a report summarising the success of its efforts during that period. It is a remarkable record, and emphasises the value of its activities not only to the graduates but to industry and the nation generally. The primary object of the Board is to secure suitable employment for the graduates of Cambridge University, but it goes a step farther and endeavours as far as is humanly possible to ensure that the right man is recommended in each case. The big industrial concerns, Government Departments, and Education Departments have readily availed themselves of the recommendations of the Board when seeking candidates for their higher posts, and from naturally small beginnings we note that one industrial group has taken into its employ no less than 73 geologists and scientific assistants from the University on the Board's recommendation ; another industrial group has taken 42 ; another has found employment for 12 chemists and physicists. Altogether in the past six years, 2,294 graduates have been found employment through the activities of the Board, of which 1034 were engineering appointments with civil engineering firms, cement manufacturers, Public Works Departments in India and elsewhere, etc. In the year 1925–26 667 graduates registered with the Board for appointments, and 396 were found suitable appointments on the introduction of the Board, so that about 60 per cent. of the graduates of the University who desired appointments were fixed up.

Concrete for Private Streets.

At a recent meeting of the Institution of Municipal and County Engineers the question of the relative cost of different types of private streets was discussed. Mr. S. G. Stanton, Borough Engineer and Surveyor of South Shields, stated that the cost of all-concrete roads in South Shields worked out at 10*s*. 8*d*. per yard super ; this was for a road varying from 7 in. to 8 in. thick with bituminous expansion joints, and included tar-dressing and sprinkling with granite chippings. His experience was that for private streets an all-concrete road 6 in. thick was the cheapest method of construction. Mr. S. E. Burgess, Borough Engineer and Surveyor of Middlesbrough, mentioned that he was using reinforced concrete for all new private street works on the ground of economy ; his practice was to prepare estimates for making up such streets in granite setts, tar-macadam, and reinforced concrete, and found that reinforced concrete was agreed to by the frontagers.

This bears out the case at Maldens and Coombe last year. In this instance certain residents objected to the construction of private streets in concrete on the ground that they would be bearing the whole cost of roads " intended for posterity." The matter was taken to court, and as a result of the action the Council was ordered to amend the specification and build the roads in water-bound macadam. Tenders were accordingly invited for the construction of the streets in different materials, with the result that when the estimates were opened it was found that the cost would be 33*s*. 7*d*. in tar-macadam, 31*s*. 4*d*. in flint, and only 28*s*. 9*d*. in concrete. The sequel was that the residents who had taken the action to court, and gained the day, withdrew their objection to all-concrete roads and requested that that material be used.

Reinforced Concrete versus Steel.

Official statistics recently issued show that since the enormous development of reinforced concrete for all kinds of construction work in the United States the output of structural steel has actually declined, in spite of the vast increase in building generally. This may be the reason for some apparently inspired articles that have appeared recently in the non-technical press. Some of these contain statements that are misleading or only half-truths. Others border on the ridiculous in their attempt to prejudice the public against reinforced concrete. Such an article, which the editor tells us was written " by an eminent exponent of the science " (of steel construction) appeared recently in a non-technical journal. After explaining that steel reinforcement was introduced into concrete "in the hope that it would supply the lack of tensional qualities in concrete," the writer states, without an attempt to produce evidence, that "in recent years it is becoming doubtful if the two materials will continue to act in conjunction with each other owing to their total dissimilar properties." The public are further told that when exposed to weather concrete "suffers seriously from disintegration, and is in fact a very perishable material." Finally, to prove that we are "living in the age of steel," we are reminded that we "cut and prepare our food with steel knives," and that railway lines are made of steel.

If the structural steel industry expects to impede the progress of reinforced concrete by the publication of such stuff as this we think they are on wrong lines altogether. The methods used to boost quack medicines and face powders are not suitable for such serious matters as a discussion of the relative merits of building materials. The absurdity of the statements needs no comment—at least until such time as there is a public demand for concrete cutlery or it is seriously suggested that railway lines should be made of concrete.

Reinforced concrete and steel each have properties that make them particularly suitable for certain purposes, and no good purpose will be served by the publication of diatribes such as that quoted above. It is one of the principles of salesmanship not to decry the other fellow's goods, and we venture to suggest that the advocates of steel construction would be more profitably employed in finding new uses for a material which reinforced concrete has rendered obsolete for so many purposes.

Effect of Lightning on a Concrete Road.

SOME notes have been published on the effect of lightning on a reinforced concrete road, known as Gulf Beach Road, in Florida. The road was constructed with ⅝-in. asphalt transverse expansion joints at intervals of 30 ft., and has a total length of 12½ miles. It is reinforced with a steel mesh reinforcement, and is laid on dry beach sand. The lightning did not pass through the slab, but travelled along the road for a distance of 780 ft. in each direction from the point struck. The only damage to the road was at the expansion joints, where there were complete gaps of 4½ in. Apparently the lightning travelled along the reinforcement as the line of least resistance. At the expansion joints it formed an arc across the ends of the longitudinal wires, which generated sufficient heat to shatter the concrete for about two inches on each side of the joint. The damage was readily made good by filling with concrete and replacing the expansion joints.

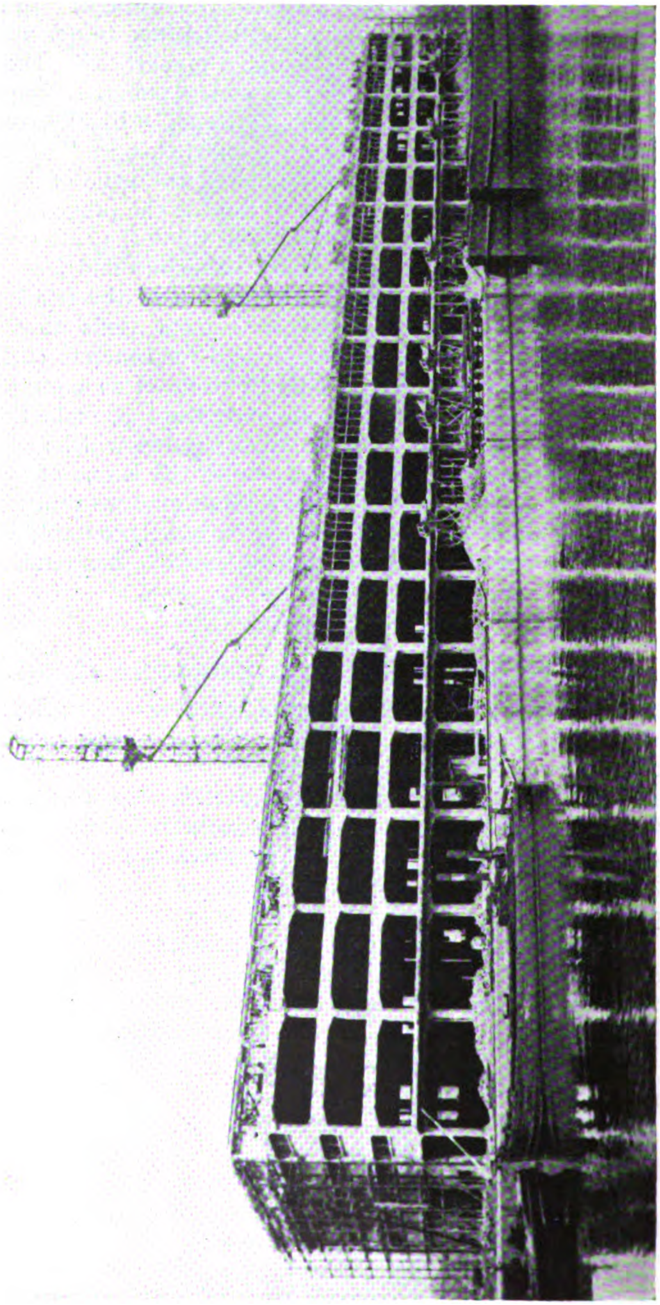


Fig. 14.—Elevation of Shed No. 7 (Dock Side). (*See p.* 353.)

Reinforced Concrete Transit Sheds at No. 9 Dock, Manchester Ship Canal.

By H. K. RUSSELL, B.Sc., Assoc.M.Inst.C.E., A.C.G.I.

THE two sheds forming the subject of this article are amongst the most important of the works recently constructed or being constructed for the Manchester Ship Canal Company.

They are on the north side of No. 9 Dock, near the head end, and are set back 38 ft. 10 in. from the waterside; this allows for three lines of track, the two inner ones for rail traffic and the outer for cranes.

The two sheds are together equipped with 26 electric cranes by Messrs. Stothert & Pitt, Ltd., 14 of the high-pedestal type on the waterside and 12 of the semi-portal type on the road side. The former run on the track nearest the dock, and can unload directly on to the fourth floor. The semi-portal type on the road side span two tracks, so that they can unload into either trucks or lorries.

The sheds are of beam and slab construction with piled foundations, and are designed for a live load of 30 cwt. per square yard. Tentative designs in the mushroom and drop-panel systems were dropped owing to the unexpected increase in loads on ground floor columns and on foundations. It was doubtful whether the saving in shuttering and labour would counterbalance the cost of the increased foundations and lower columns.

Each shed has four stories, and is 450 ft. long by 110 ft. wide centre to centre of columns. The height from ground floor level to first floor level is 17 ft. 0¼ in., and between the upper floors 10 ft. 11¾ in.

The sheds are open for their whole length on the dock side; this is cut down by half on the road side, where openings occur only in every other bay. Openings and doorways are provided with sliding fire-proof steel doors made from ¼-in. plate heavily stiffened with tees and

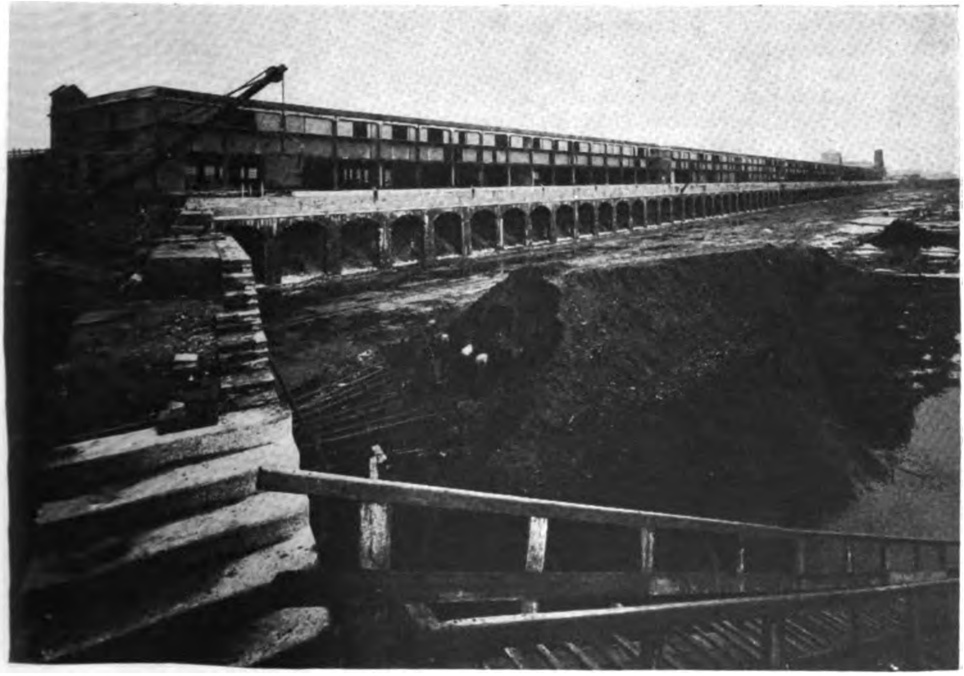


Fig. 1.—No. 9 Dock during construction—looking towards the West.

angles. The doors are fitted with ball-bearing wheels running in special cast-iron grooves, and, though in some cases weighing approximately one ton (as on the ground floor), are easily moved by one man. On the dock side the doors are arranged to run from end to end, so that half the whole shed is available for loading or unloading at one time.

Staircases are enclosed within 4-in. walls running right up to the roof. Similarly a 4-in. central division wall with double sliding doors runs up to the roof and 3 ft. beyond, and divides each shed in two. In the event of fire one half of the shed can be completely cut off from the other and the affected floor completely isolated.

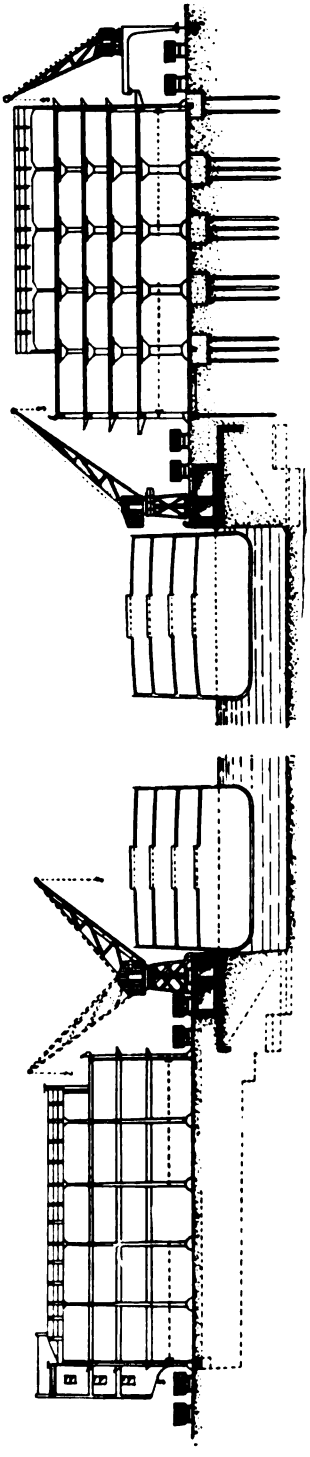
The roof is of the ridged type with a rise and span of 3 ft. 8½ in. and 25 ft. respectively, and is stepped back one bay on the dock side, leaving part of the fourth floor uncovered. The meshed roof slab is 2½ in. thick and rests on 7 in. by 3 in. purlins. The supporting principals are spaced at 7 ft. 4 in. centres. They are of semi-arch shape, 1 ft. 11 in. deep at the crown, 1 ft. 3 in. deep at the springings, and 4 in. thick.

The first floor is extended on dock and road sides to form loading platforms. The road-side platform carries one leg of a semi-portal crane on a continuous beam which is comparatively massive, as it is 24 in. deep by 12 in. wide for a span of only 6 ft. 3 in. The beam supports are formed by a prolongation of the secondary floor beams. The other leg of the crane is supported by a still more massive continuous beam in the middle of the roadway, 970 ft. long, resting on single piles spaced at 15-ft. centres and driven to rock.

The floor slabs in the upper floors are 6 in. thick and are reinforced with ⅜-in. diameter rods spaced at 5-in. centres. The ground-floor slab is 9 in. thick, and with the exception of the bay nearest the dock is of plain third-class concrete spread on a 3-in. layer of ashes well watered and rolled. The exception, owing to its nearness to the earth slope, is of second-class concrete, reinforced and supported on beams.

The floors are asphalted, the ground floor with 1¼ in. and the upper floors with ¾ in. The roof is covered with ¾ in. of asphalte laid on in two layers.

The main beams are 25 ft. in span and run longitudinally. They are 31 in. deep



Old Sheds on South side.
New Sheds, Nos. 7 and 9, on North side.
(Note.—Beam and slab construction adopted instead of drop panel system shown. See Fig. 4.)

Cross Section No. 9 Dock.
Fig. 2.

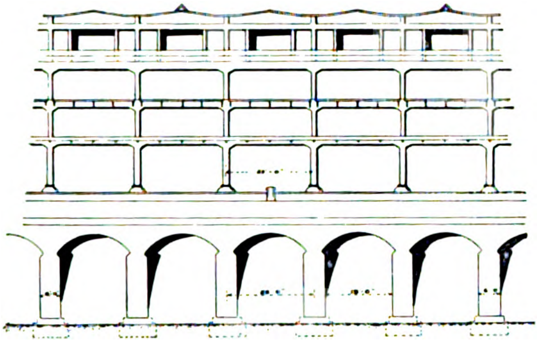


Fig. 3.—Elevation of Old Sheds and Dock Wall on South side.

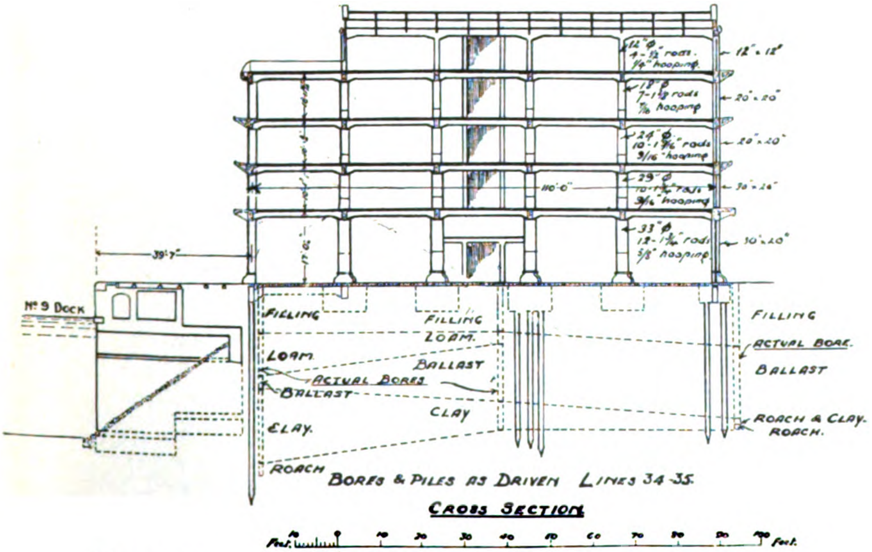


Fig. 4.—New Transit Sheds, Nos. 7 and 9. Cross Section.

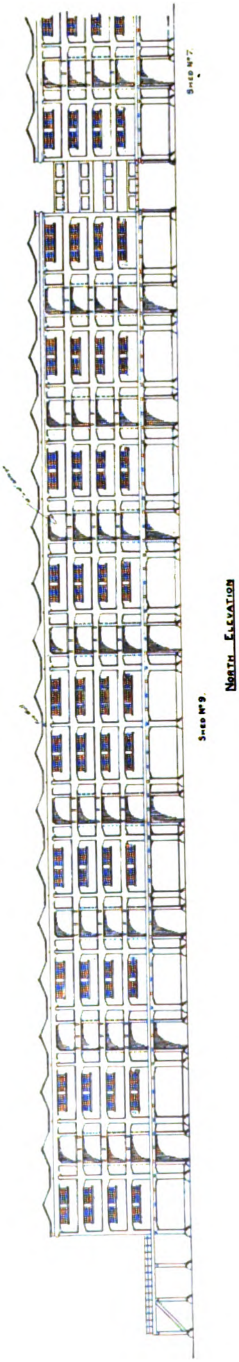


Fig. 5.—New Transit Sheds, Nos. 7 and 9, North Elevation.

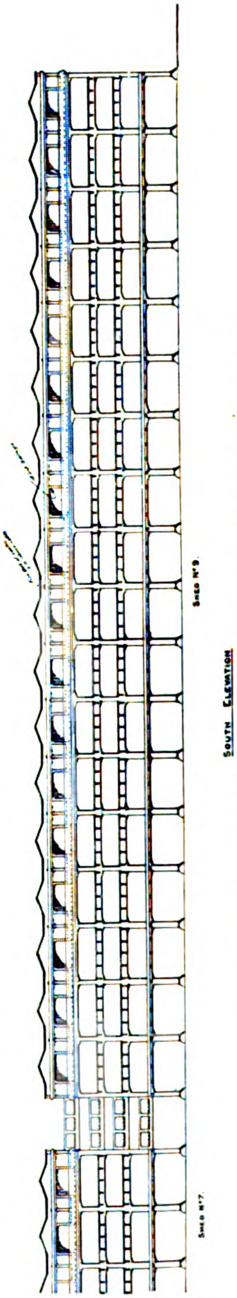


Fig. 6.—New Transit Sheds, Nos. 7 and 9, South Elevation.

and 16 in. wide, and are doubly reinforced with ten 1⅛-in. diameter bottom rods with ⅜-in. diameter stirrups, and five 1¼-in. diameter top rods.

All the inside columns are circular in section. They range from 33 in. successively through 29 in., 24 in., 18 in. to 12 in. diameter on the fourth floor. The ground floor columns are heavily reinforced with twelve 1¾-in. diameter rods and ⅝-in. diameter helical hooping of 2-in. pitch. The pitch distance is standard throughout all columns except on the fourth floor, where it is increased to 3 in.

The rectangular outside columns are 30 in. by 20 in. and diminish to 20 in. by 20 in. on the two uppermost floors. The R.I.B.A. formula

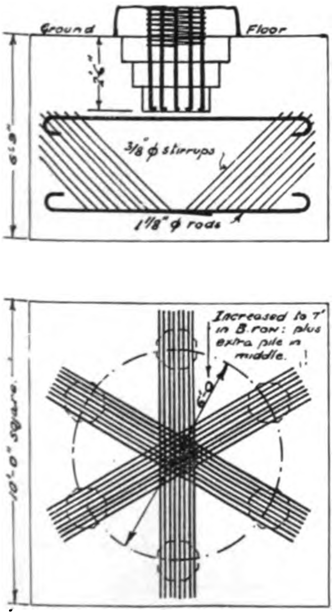
$$P = c(1 + fsr)[A_c + (m - 1)A_s]$$

for short columns was used in their design.

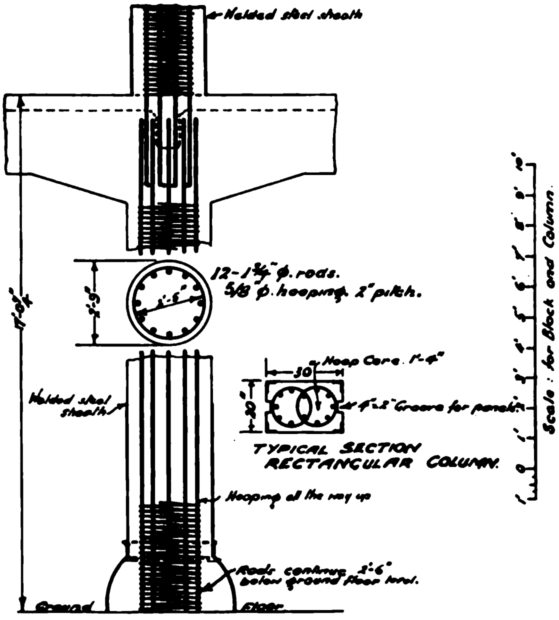
In computing the loads on columns the following practice was adopted: the top-floor area is regarded as 100 per cent. loaded, the next 90 per cent., the next 80 per cent., and so on, till a minimum of 50 per cent. is reached, at which it remains for the remaining floors.

Where wall panels occur they have been made discontinuous with the neighbouring columns—grooves being formed in the latter to take the sides of the panels. At top and bottom edges, however, the panel steel is continued into the floor beams. In spite of the precautions taken at the junction with columns the large panels on the ground floor show contraction cracks. It would appear that the tendency for panels to crack can only be overcome by making all large panels entirely separate units; that is, with a break along all four edges.

The uncommon form of the dock wall largely determined the type of foundation chosen for the sheds. "Dock wall" is really a misnomer, for the structure actually consists of a series of continuous concrete arches 1 ft. 6 in. below dock water-level, supported on concrete piers 6 ft. wide, 36 ft. 8 in. deep from front to back, and at 25 ft. centres. The pier footings are founded on stiff clay at varying levels. At the back a vertical curtain wall integral with arch and pier extends 8 ft. 9 in. downwards from the crown. On top of the arches are two subways, the outer and smaller of which houses the various hydraulic and water supply mains and the electric power cables. The inner



FOUNDATION BLOCK.
Fig. 7.



GROUND FLOOR COLUMN (Inside)
Fig. 8.

New Transit Sheds, Nos. 7 and 9.

and larger subway houses the grain belts that feed the large grain elevator at the head of the dock. The roofs of these two subways form the solid portion of the quay, the interval between the latter and the shed face being simply well-rammed earth-fill. From the curtain wall to the face of the dock "wall" the earth lies at its natural slope.

When first built the piers on the other side of the dock were extended at gravel level to form mass concrete foundations for the sheds that immediately followed. This is clearly shown in *Fig.* 2. This work was done in the dry. On the north side, however, the piers were left normal. In the case of the two new transit sheds similar foundations would have involved working below dock water level, the forming of an unsatisfactory joint between new work and old, and incidentally very heavy excavations owing to the big increase in the ground level—from arch to quay—since the earlier construction days. Piled foundations were therefore adopted. The heavier column loads due to a fourth story and the comparative nearness of the rock surface favoured this type of foundation.

In the inner foundations the piles are driven in groups of six arranged circumferentially (with an extra central pile in the second row from the dock), and in the outer foundations in groups of four.

Heavily reinforced concrete blocks cap the groups. The reinforcement consists

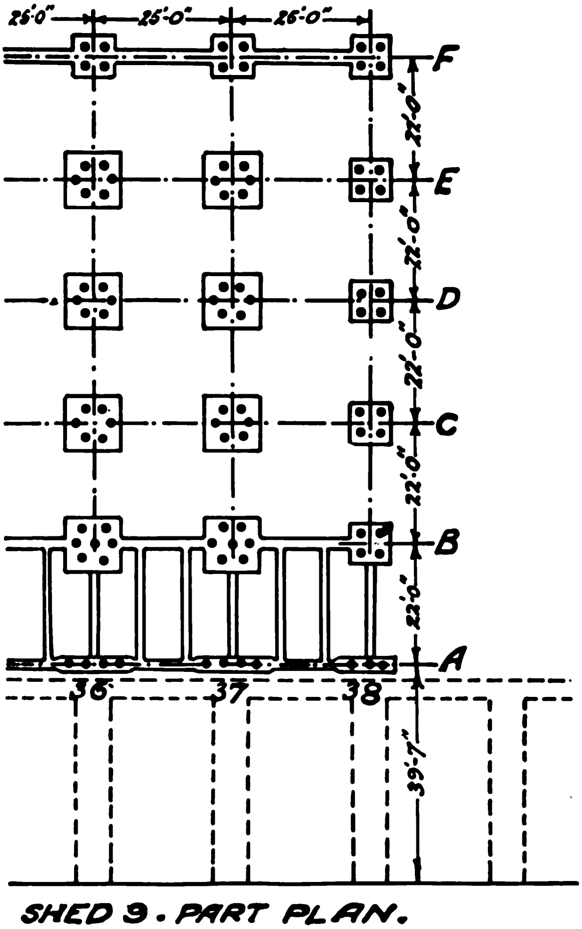


Fig. 9.

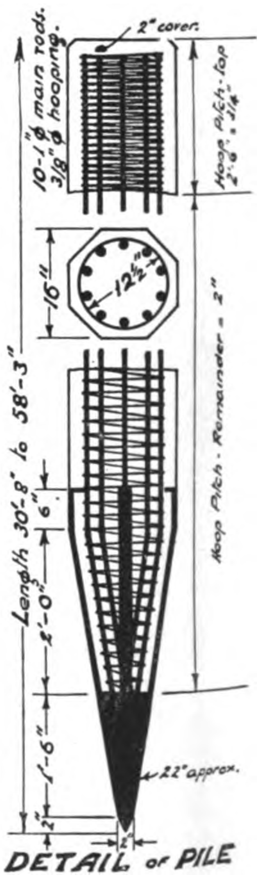


Fig. 10.

New Transit Sheds, Nos. 7 and 9.

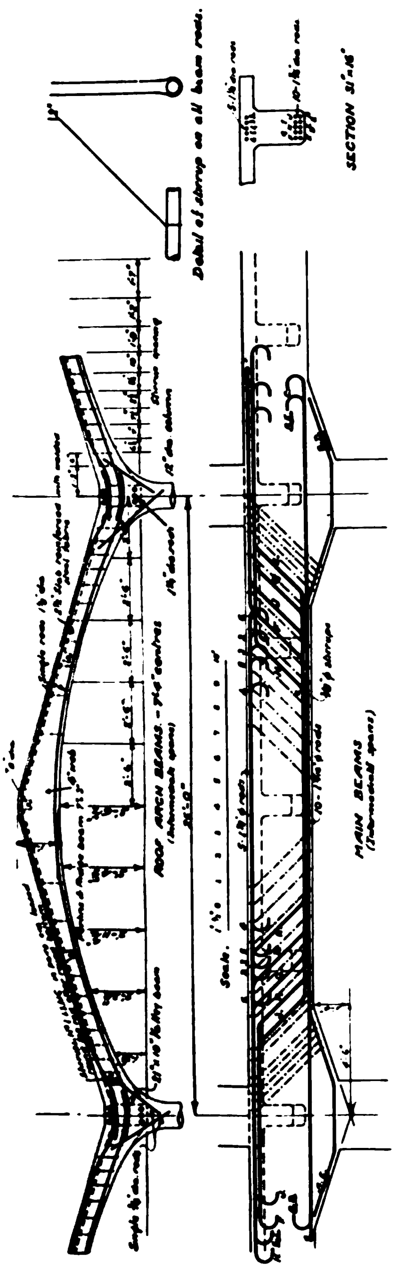


Fig. 11.—Roof Arch Beams and Main Beams.

of a radial mat of 1¼-in. diameter rods threaded through the previously-exposed pile rods. The inner blocks are 10 ft. by 10 ft. by 7 ft. 6 in. deep and the outer 7 ft. 6 in. by 7 ft. 6 in. by 5 ft. deep.

The piles are of 16-in. octagonal section reinforced with ten 1-in. diameter rods and ⅜-in. diameter spiral hooping of 2-in. pitch. They vary in length from 30 ft. 8 in. to 58 ft. 3 in., and were precast in special 10-ft. long steel shutters clamped to a wood " bed " of the same width as the pile face. The shutters were struck in 48 hours. The piles were lifted and stacked four weeks after the date of moulding and driven on the sixth.

The heaviest driving was through the ballast. The pile heads received such severe punishment that in a very large proportion of cases they spalled badly—in two or three cases for as much as 12 ft. down—necessitating the deepening of the foundation blocks to cover the exposed steel.

Two experimental piles in aluminous cement, 47 ft. 8 in. and 41 ft. 8 in. long respectively, were pitched and driven 72 hours after moulding. They stood up to the heavy driving as well as the ordinary piles, that had been left to mature for two months.

Driving began simultaneously at both ends of the site, with two 3¼-ton and one 4¼-ton drop monkeys and one 3-ton semi-automatic. The last was found to handle the piles at a lesser rate than the others. The maximum work done by the two most efficient frames at their best period worked out at 2¾ piles per frame for a 12-hour day.

As a result of the displacement of the ground due to the pile driving the dock wall was forced out a maximum of 1½ in. opposite approximately midway between the two sheds. The wall was, however, still plumb after movement.

The contractors for the superstructure introduced a number of interesting features into their work. They adopted a system of angle-iron scaffolding which they have patented. The nucleus of this is a group of four vertical angles erected round a column and joined together with horizontal angles under the beams. The latter support timber cross-pieces on which the bottom of the beam shuttering rests, the sides of the beam shuttering being firmly wedged against chogs screwed to the ends of the cross-pieces. This

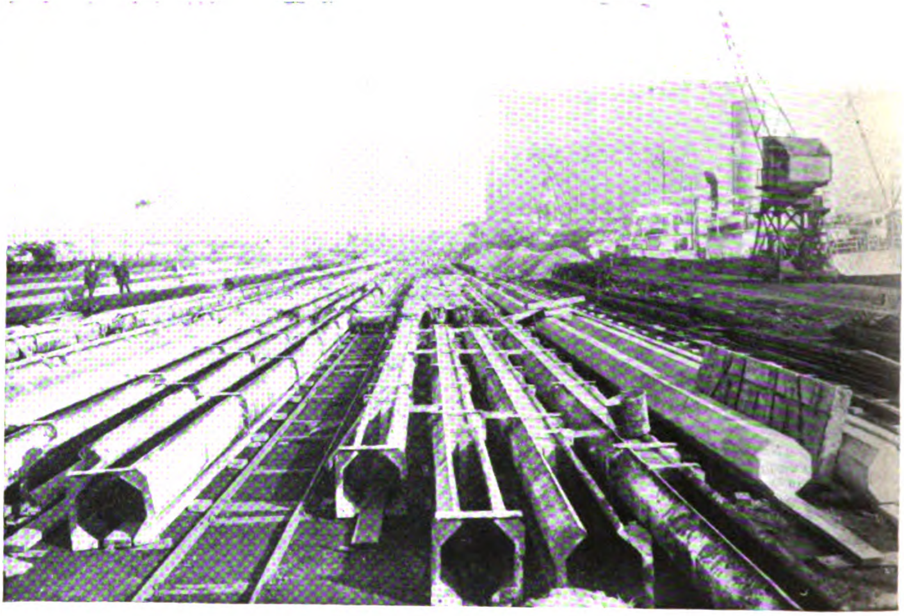


Fig. 12.—Steel Moulds for Casting Piles.

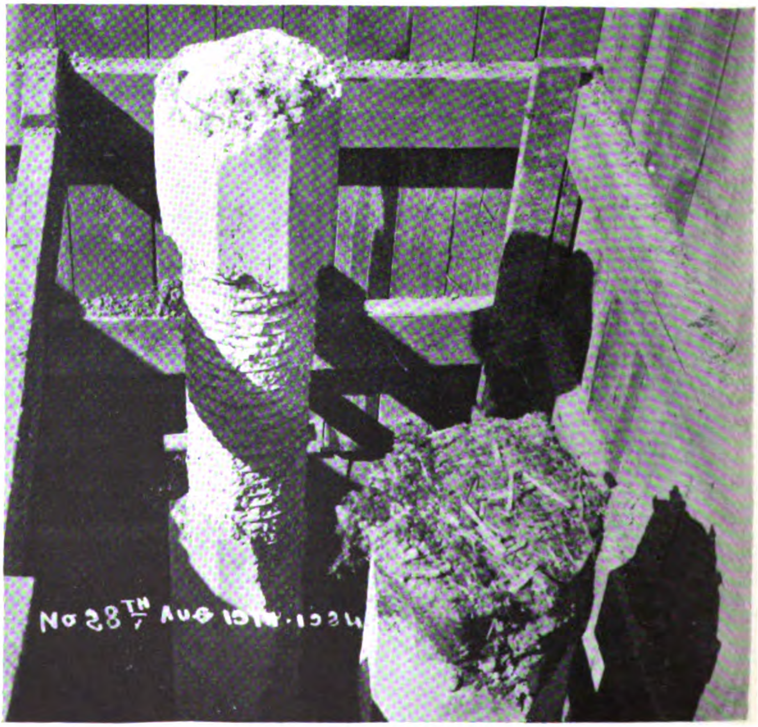


Fig. 13.—Two of the Piles, showing Spalling.

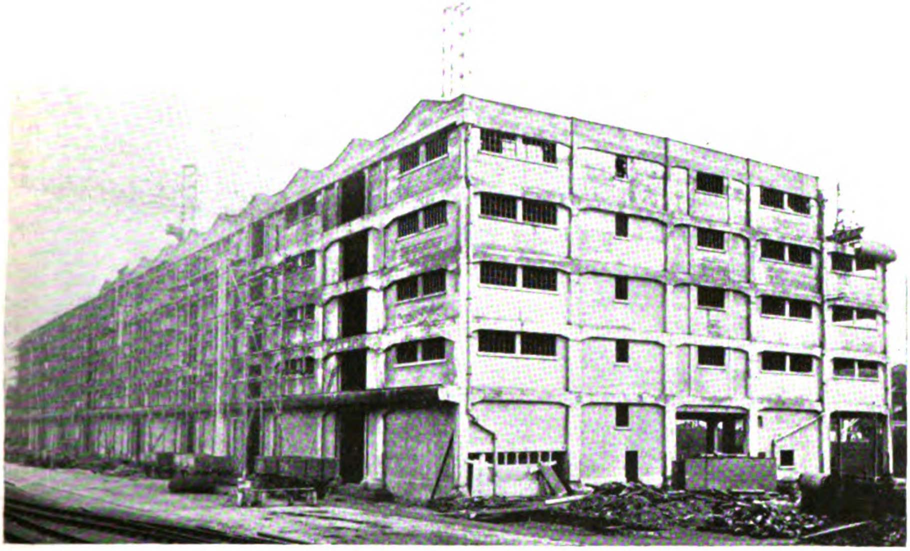


Fig. 15.—View of Part of Shed No. 7.

system effected considerable saving in time over ordinary timber propping methods, as the frame work, when erected, formed a rough template for the carpenters to work to, eliminating much labour in lining and plumbing. The contractors claim a great saving in labour cost owing to its use (see *Fig.* 16).

The shuttering for the first floor was formed of a number of factory-made panels 5 ft. 5 in. by 2 ft. 11¼ in. wide dropped into position on the beam shutter sides. These did not prove a success as there was a tendency for panels to move unequally when concrete was poured and form bad joints. They were scrapped after use on the first floor.

The column forms were of $\frac{1}{16}$ in. steel in three vertical sections. Special steel "bonnets" formed the upper portion of the columns and beam haunches.

Distribution of the concrete was effected by means of two Insley distributing towers 140 ft. high—both in one shed. The concrete had to be on the wet side to flow satisfactorily. A considerable portion of the aggregate was inclined to separate from the advance portion of the first batch of the day's output, and had to be remixed on a platform at the point of discharge. After this first batch the chute became lubricated and the trouble tended to disappear.

Column and panel forms were struck in three days, and the sides of beams and undersides of slabs in 14 days. Undersides of beams were left supported for three weeks—six weeks if any loading was brought on the beam within this period.

Immediately after stripping, surfaces were rubbed down with carborundum blocks and cement washed. Generally, however, the surfaces were so good as to need very little rubbing.

All walls and ceilings were then sprayed with two coats of limewash which enhances the bright and airy appearance of the interior.

Three different proportions of concrete were used in the sheds :—

Class I.		*Class II.*	
Cement .	810 lbs.	Cement .	694 lbs.
Sand .	13½ cu. ft.	Sand .	13½ cu. ft.
Aggregate	27 cu. ft.	Aggregate	27 cu. ft.

Class III.

Cement	608 lbs.
Sand	13½ cu. ft.
Aggregate	27 cu. ft.

The first-class concrete was used for the columns and piles, and the third class for the unreinforced portion of the ground floor. All the remainder of the work was in second-class concrete.

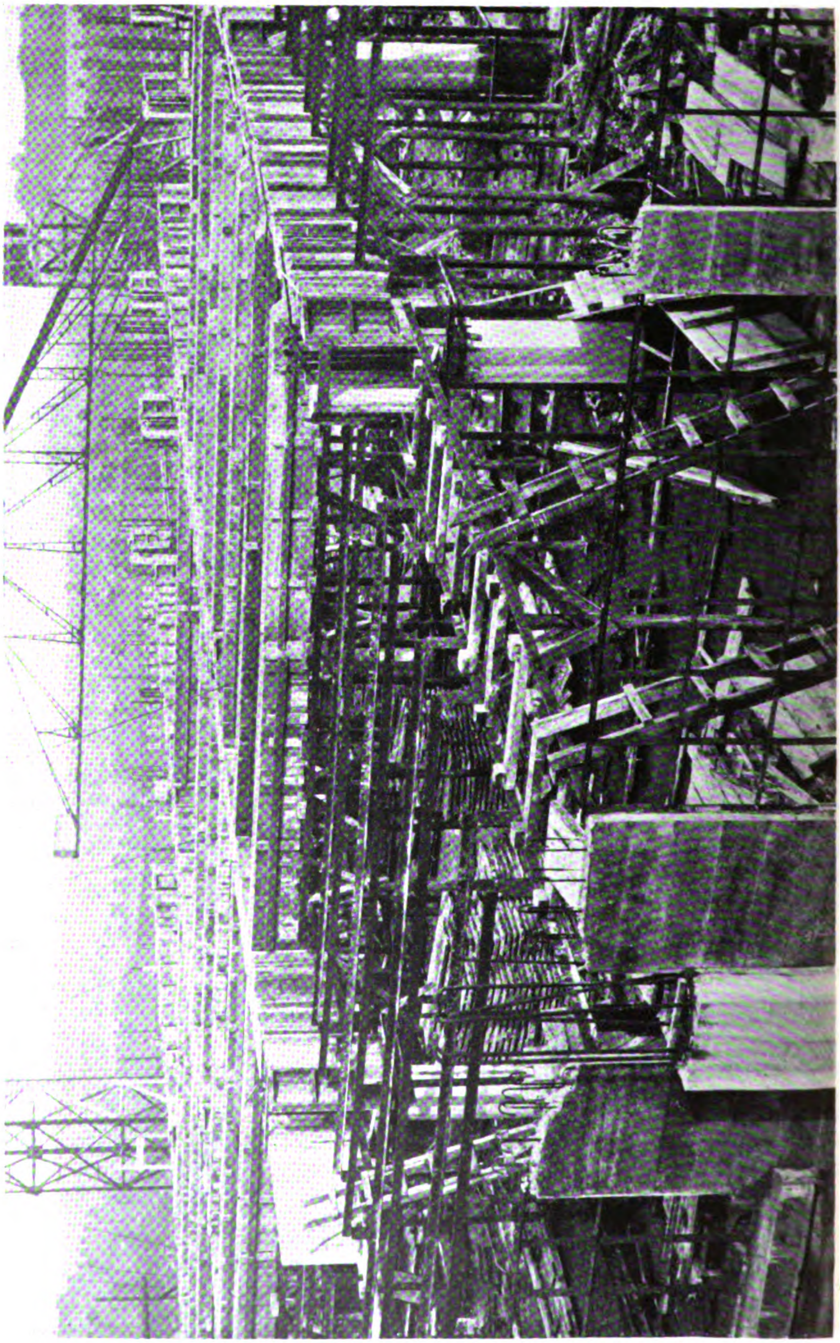


Fig. 16.—View showing Special Angle Scaffolding.

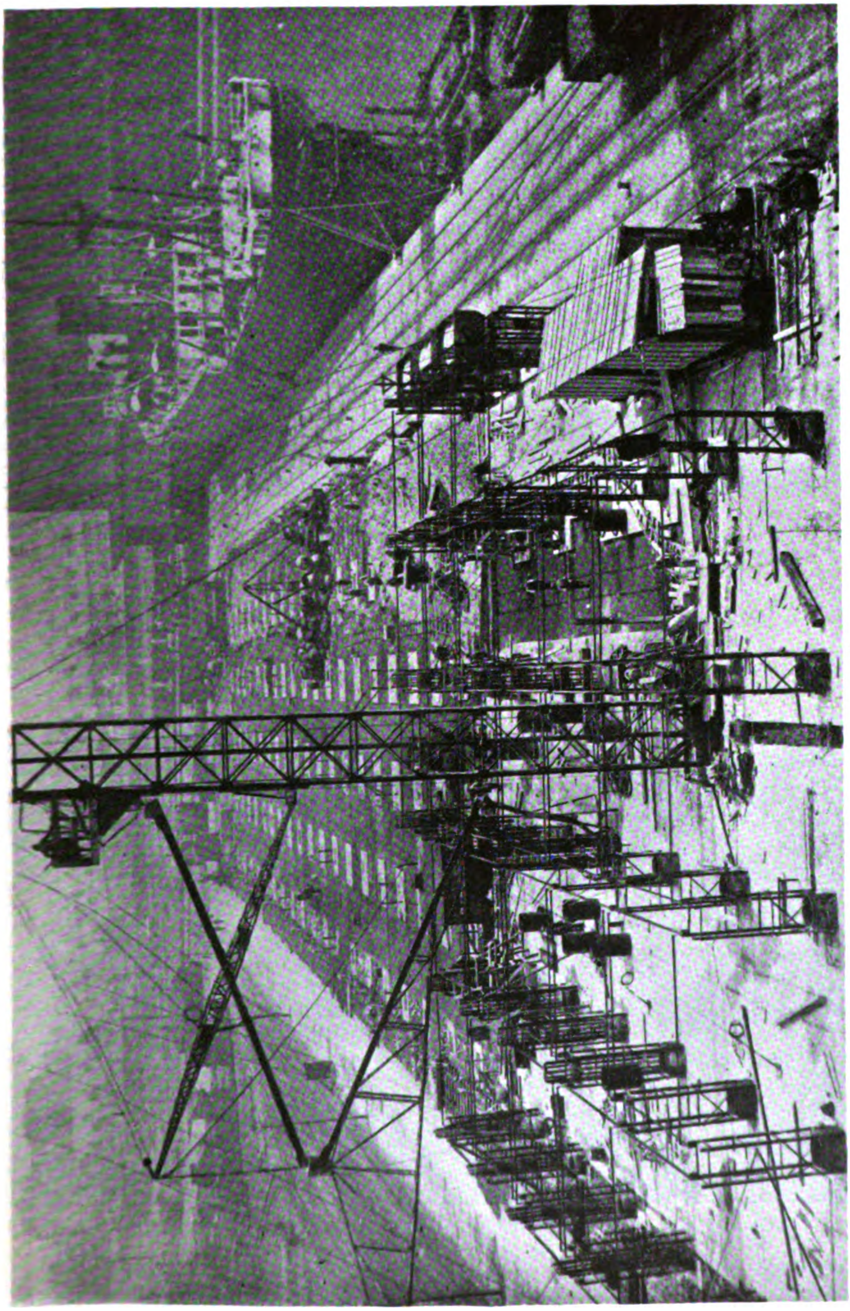


Fig. 17.—Ground Floor, showing Foundation Blocks and Plain Slab Floor.

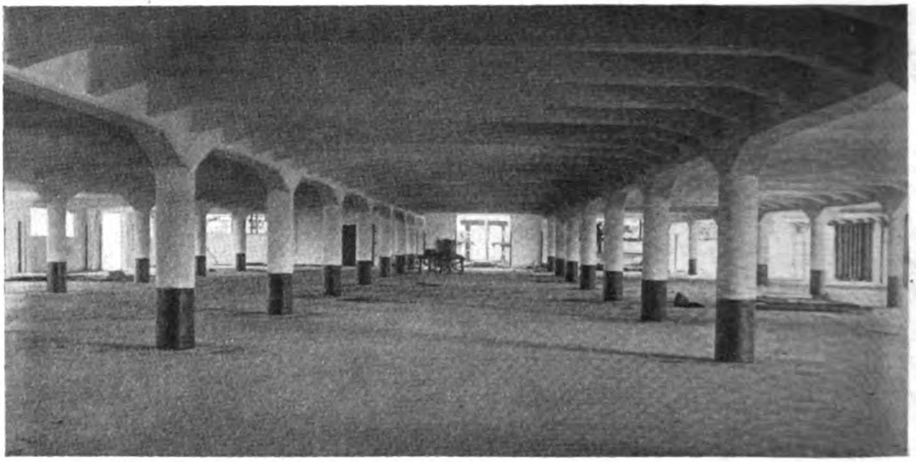


Fig. 18.—An Upper Floor.

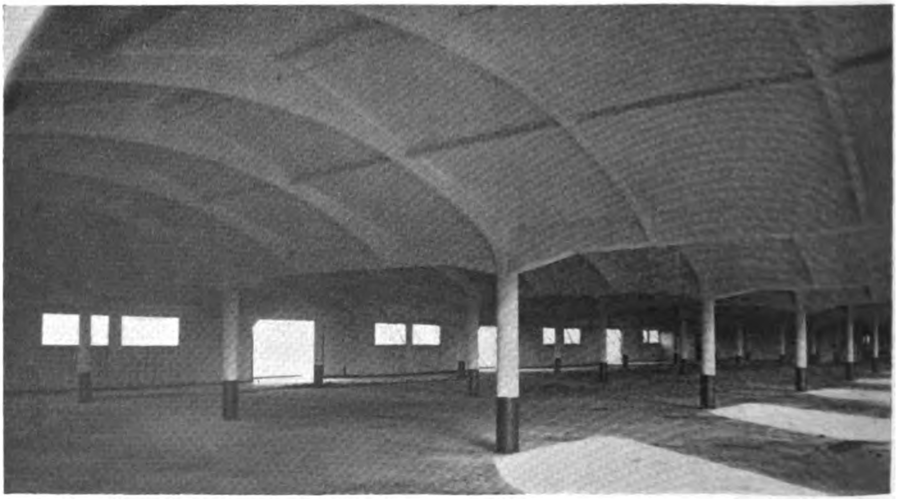


Fig. 19.—Roof Story.

The aggregate was ¾-in. Welsh granite for first and second class mixes, and 2-in. Darley Dale sandstone for the third class mixes. The sand was River Mersey sand. Reinforcement was supplied by the United Strip & Bar Mills, Ltd.

The contractors for the foundations were Messrs. Sir Wm. Arrol & Co., Ltd., of Glasgow, while Messrs. B. Morton & Sons, of Manchester, were responsible for the superstructure.

The work was carried out under the direction of Mr. H. A. Reed, M.Inst.C.E., Chief Engineer to the Manchester Ship Canal Co., to whom the author desires to express his thanks for permission to write this article. The Resident Engineers for the contractors were Messrs. M. G. Sutherland, Assoc.M.Inst.C.E., and R. H. Garvie, M.Inst.C.E., for Messrs. Arrol and Morton respectively. Mr. G. Leader Williams, Resident Engineer for the Docks Division, acted for the Canal Company, and the author was his assistant engaged upon the actual works.

Plastic Yield and Shrinkage of Concrete.

A PAPER by Dr. Oscar Faber, O.B.E., D.Sc., M.Inst.C.E., to be brought forward for discussion during the present session of the Institution of Civil Engineers, entitled " Plastic Yield, Shrinkage, and other Problems of Concrete, and their Effect on Design," is abstracted as follows in the abstracts of papers issued by the Institution :

The author studied a series of beams of reinforced concrete, loaded to various stresses. The deflections, instead of remaining constant, increased in 36 weeks to 2⅔ times their value when the loads were first applied, though the loads remained constant. The causes of this are analysed (with the assistance of extensometers), and it is shown that the shortening of the top flange consists of three parts, namely, (*a*) the elastic strain, (*b*) the plastic strain, and (*c*) the shrinkage.

It is shown that (*a*) is the stress divided by a modulus of 4 million lbs. per sq. in. ; (*b*) is proportional to the stress and (from 4 to 36 weeks) is nearly double (*a*) ; (*c*) is independent of stress, but between 4 and 36 weeks has a value about double the elastic strain, corresponding to 600 lbs. per sq. in.

With a stress of about 600 lbs. per sq. in., the total shortening (0 to 36 weeks) is about six times that due to the elastic strain (the only one normally calculated).

The effect of this on stress is discussed, and it is shown that in columns the stresses are far greater on the steel, and much less on the concrete, than ordinarily calculated.

An example is taken, showing a steel stress of 23,350 lbs. per sq. in., compared with a stress of 4,230 lbs. per sq. in. as ordinarily calculated, without taking shrinkage or plastic yield into account (taking $m = 7\frac{1}{2}$ in both cases). This conforms with stress-measurements made on actual buildings over long periods. Consequently, present calculations and regulations leave much to be desired.

Whereas Young's modulus for concrete is generally higher than usually taken, stresses (after shrinkage and plastic yield have occurred) approximate to those obtained with a very low modulus.

Formulas are given from which stresses due to shrinkage, plastic yield, and elastic strain may be calculated for beams and columns ; and examples are given. The nature of plastic yield is discussed, also the conditions likely to control its extent. It is shown that concrete structures must not be expected to return to their original deflection after being loaded for long periods. The safety of reinforced-concrete structures is discussed.

Reinforced Concrete Bridge at Montrose.

THE Montrose Town Council and Forfar County Road Board have resolved that a new bridge over the river South Esk at Montrose, to supersede the present suspension bridge, be constructed of reinforced concrete to the design of Sir Owen Williams. The cost is estimated at £73,450, which is £4,550 below that for a steel girder structure.

Institution of Structural Engineers.

The President (Mr. H. J. Deane) occupied the chair at the annual dinner of the Institution of Structural Engineers on May 16, when a large gathering of members and friends spent a most enjoyable evening.

The guest of the evening was Lord Carson, who replied to the toast of "Our Country and Empire" (proposed by Major A. H. S. Waters, V.C.). Lord Carson recalled that his father was an engineer, and that in his early days he commenced training as an engineer. But his father induced him to forsake engineering in favour of the law—otherwise he might have become the greatest engineer of them all! Thus he was early interested in construction, as all men must be, for construction was the only thing that gave pleasure in life. Whether one erected great dams and bridges, or only constructed a case, one was engaged in the great work of construction.

Sir Ernest Moir, Bart., proposing "Our Guests," mentioned that he was connected with Benjamin Baker and Sir William Arrol in the erection of the Forth Bridge; their example had been a guiding star to engineers who had followed them. The Forth Bridge was the most scientifically designed bridge that existed to-day, although it was built so long ago as 1887.

Mr. Frederick Palmer (President of the Institution of Civil Engineers), in replying, referred to the application of the Institution of Structural Engineers for a charter, and said they had opposed the measure, not because of any professional jealousy, but because they thought it in the best interests of engineering that the measure should be opposed. They did not object to the Institution of Mechanical Engineers or the Institution of Electrical Engineers having charters, because the work of the members of those institutions was different from the work of civil engineers. But the proposal that the Institution of Structural Engineers should have a charter was in a different category, for if civil engineers were not structural engineers he did not know what were the duties of the members of the Institution of Civil Engineers. They opposed the measure because they wished to avoid any confusion in the use of the words "Chartered Engineer." The Royal Institute of British Architects was applying, in Parliament, to have the position of architects strengthened and made clear, and the Institution of Civil Engineers was opposing that measure also. The Institution felt that a great deal of the work of its members might come under the description of architectural work. He had personally been associated with the construction of buildings for railways and harbours, and he was quite sure that if that type of work were taken from engineers many of them would have to seek other careers. In conclusion, he expressed a hope that there would in future be more unity amongst engineers. He was convinced that the sooner the various engineering institutions got together and came under one flag the better it would be for engineers as a whole.

Sir Henry Fowler (President of the Institution of Mechanical Engineers), proposing "The Institution of Civil Engineers and its President," said he had been greatly impressed recently by the beauty of most of the new reinforced concrete structures, particularly bridges, which were so well designed that they appealed to the eye of people who were not engineers.

The reply by the President concluded the first part of the programme, which was followed by a musical entertainment.

"The Wonders of Wilmington."—Mr. Heath Robinson finds more amusement in the manufacture of Portland cement than most of those engaged in the scientific and highly-organised processes employed in a modern cement works, and some of his impressions of Messrs. G. and T. Earle's works at Wilmington have now been published in book form. Those who have been amused by these drawings when published in the firm's advertisements will be glad to have them printed on large sheets of excellent paper and strongly bound. They are done in the typical "Heath Robinson" style, and in his own inimitable way he gives us wonderful impressions of what life, and cement making in particular, might be if humour took the place of efficiency in industry. The works manager who interleaves these drawings with his costing and output data will be rewarded with many a gleam of sunshine when it is most needed.

Rapid-Hardening Concretes.

Some Practical Notes on Their Use.

By W. L. SCOTT, M.Inst.C.E.

THE use of rapid-hardening concrete is becoming more and more general by engineers and contractors now that the advantages it gives over the ordinary variety are shown by experience to be economic in several ways and for almost all kinds of construction.

Such concretes, of course, derive their rapid hardening properties from the cement used. These cements may be divided into two classes, viz. what may be conveniently called improved Portland cement, and aluminous cement. The former is a pure Portland cement conforming to the requirements of the latest British Standard Specification, whilst the latter is entirely different in character, both as regards its composition and manufacture, and concrete made from it, whilst having the common advantage of increased strength at a much earlier age, must be regarded essentially as a different material.

By referring to the concrete as rapid hardening, it must not be thought that it is consequently quick setting, for this is not the case. All rapid-hardening cements conform to the requirements of the British Standard Specification for Portland Cements in this respect.

Rapid-hardening Portland Cement Concrete.

Concrete made with rapid-hardening cements of the Portland variety has so many advantages over ordinary Portland cement concrete, and the increase in cost is so small, that its general adoption can only be a question of time. Actually, these cements are a superior grade of Portland cement. They do not obtain their valuable properties from any one operation in manufacture, such as fine grinding, as is popularly understood. In point of fact, their rapid-hardening qualities are derived from the general improvement in manufacture in all its stages. A greater proportion of lime is added, but the quantities still conform to the requirements of the latest British Standard Specification and enable it to be described as a true Portland cement. The above remarks do not seem generally to be appreciated by engineers, probably owing to lack of emphasis on the part of the manufacturers in advertising the product.

Increased Strength.—The ultimate strengths of concrete made from rapid-hardening Portland cements show very considerable increases over ordinary concrete, while in the early stages the increase is incomparably greater. At four days after deposition the former acquires a strength equal to or greater than the latter when 28 days old.

Published tests also show that these rapid-hardening concretes increase in strength over long periods at as great a rate as, or even greater than, ordinary Portland cement concrete. This point is of obvious importance in showing that, although very high results are obtained at early periods, there is no retrogression in strength over long periods.

Tests on 6-in. laboratory-made cubes, with 4 : 2 : 1 rapid-hardening Portland cement concrete, gave the following results :—

Age.	Strength.
1 day	1750 lbs. per sq. in.
2 days	2910 ,, ,, ,, ,,
3 ,,	3853 ,, ,, ,, ,,
5 ,,	4840 ,, ,, ,, ,,
7 ,,	5360 ,, ,, ,, ,,
28 ,,	6810 ,, ,, ,, ,,
6 Months	7260 ,, ,, ,, ,,
12 ,,	7490 ,, ,, ,, ,,

Cold Weather Concreting.—A point of considerable importance in concreting during cold weather is the heat generated in setting and during the first few days of maturing. It has been shown that rapid-hardening concretes generate heat more rapidly than does the ordinary variety, and in consequence such concretes are more immune from the detrimental effects of frost.

Work has been carried out on a large scale under wintry conditions with rapid-hardening Portland cement, the only precautions taken being to heat the mixing water and protect the concrete for the first few hours after deposition. No trouble was experienced, in spite of the fact that the temperature during this time was only a little above freezing point, with considerable frosts occurring at night.

Water Content.—In mixing rapid-hardening Portland cement concrete, as little water should be used as is consistent with the work being done, provided plasticity is obtained. An excess of water beyond this amount results in loss of some of the rapid-hardening properties and a permanent reduction in its ultimate strength.

Economy in Formwork.—The advantages of using a rapid-hardening Portland cement in place of ordinary Portland cement are obvious from many points of view. The following list gives the times at which either concrete can be made use of or shuttering stripped.

	Rapid-Hardening P.C. Concrete.	Ordinary P.C. Concrete.
Strip vertical walls	1 day	2–3 days
,, columns	1 ,,	2–3 days
,, centering from suspended floors	2–4 days	14–28 days
,, soffits to secondary beams	3–4 ,,	14 ,,
,, soffits to main beams	6–7 ,,	28 ,,
Lift reinforced concrete piles	3–4 ,,	28 ,,
Drive reinforced concrete piles	7 ,,	6–8 weeks
Roads to carry traffic	4 ,,	14–28 days

Watertightness.—Recent tests carried out by the Department of Scientific and Industrial Research, under Dr. R. E. Stradling, show that rapid-hardening Portland cements possess the property of making a watertight concrete more readily than does ordinary Portland cement. These tests are embodied in Technical Paper No. 3, entitled "The Permeability of Portland Cement Concrete." and summarised in appendix 9. This fact is of particular importance for reinforced concrete work in sea water.

Aluminous Cement Concrete.

Until fairly recently there was insufficient practical experience in this country, and, for that matter, abroad, of the properties and behaviour of concretes made with the two kinds of rapid-hardening cements. Laboratory experiments and tests, of course, had been made, but these were not enough in themselves to convert engineers to their use, except, perhaps, for some small and unimportant jobs.

Moreover, in the case of aluminous cement, there were several difficulties to be overcome in manufacture before the makers could with confidence market the material. There is, however, no doubt that this material as sold to-day has remarkable properties and produces a concrete which is for some work unique in its suitability.

Its principal property is intense hardness in a very short period, viz. 24 to 48 hours. Reinforced concrete piles can be driven at the latter time, and this admittedly provides the severest known practical test upon the concrete.

Strength.—The crushing of a series of laboratory test cubes made with 3 : 1 standard sand and aluminous cement showed the growth in strength to be as follows :—

Age.	Strength.
3 hours	43 lbs. per sq. in.
5 ,,	1410 ,, ,, ,, ,,
7 ,,	3700 ,, ,, ,, ,,
12 ,,	5700 ,, ,, ,, ,,
24 ,,	7430 ,, ,, ,, ,,
3 days	7580 ,, ,, ,, ,,

It will be seen, therefore, that the concrete acquires a hardness sufficient to permit the removal of centering, etc., in about 7 hours. This, in fact, has been done successfully in actual construction.

Watering During Hardening.—For concrete made with aluminous cements there are one or two essential precautions to be taken. The concrete must be kept thoroughly flooded with water immediately after setting and during the early hardening period.

The temperature of the material rises to a much greater extent than Portland cement concrete, averaging about 100° Fah., which is reached in about 10 hours. For the above reasons difficulty may be met with in concreting large masses having minimum dimensions exceeding 18 in. to 24 in. It is difficult properly to supply with water the centres of such masses during the setting period, and if this is not done efficiently the strength of the interior concrete suffers accordingly.

Generation of Heat.—Although no figures appear to be available, it is thought that the total heat generated by all cements during the hardening period is about the same. The lengthy period of hardening of ordinary Portland cements, however, in most cases permits the dissipation of the heat without any appreciable rise in the temperature of the concrete.

Mixing Portland and Aluminous Cements.—It is vitally important to prevent the mixing of aluminous cements with Portland cement, whether intentionally or unintentionally, such as contamination of one by the other when stored together—in fact, it is desirable for engineers to specify separate stores for these cements.

Care should also be taken to see that the concrete mixers and chutes are thoroughly cleared of Portland cement concrete before they are used for aluminous cement concrete. A contamination of about 5 per cent. is sufficient to produce a mixture having a " flash " set.

A further necessary precaution is to ensure the proper setting of Portland cement concrete before the deposition of aluminous cement concrete in contact with it is permitted, and vice versa.

Proportions.—As regards suitable mixtures for aluminous cement concrete, it is considered, having regard to its peculiar properties, that nothing richer than 4 : 2 : 1 should be specified. A richer mixture than this is uneconomical with the strength already available, and the rise in temperature, being produced entirely by the cement, must increase with the cement content. Shrinkage is also greater with rich concretes.

An advantage obtained by the use of concrete made with aluminous cement, which has nothing to do with its rapid-hardening properties, is the ability to mix and deposit concrete satisfactorily during temperatures much lower than those possible with ordinary concrete. There is also an increased capacity to withstand the action of certain acids ; in fact, it was with the object of producing an acid-resisting concrete that the earlier experiments resulting in the production of aluminous cement were made.

Restrictive Regulations.

At present, the greatest economy cannot be realised for a large amount of building construction work in this country owing to the form of the various regulations governing the permissible stresses to be employed for concrete. This is particularly the case with the existing L.C.C. Regulations, which cater only for concrete made with ordinary Portland cement. No matter what strength a concrete proposed to be employed may be demonstrated to possess, the stresses permitted under these regulations are limited to a fraction of the presumed ultimate stress of a concrete which in fact may bear no relation to that in question. This state of affairs is indefensible and should be remedied without delay.

As an illustration of this, under the L.C.C. regulations the allowable compressive stress upon concrete having a mix of 4 : 2 : 1 is 600 lbs. per square inch. This is based upon an assumed crushing resistance for the material of 2,400 lbs. per square inch four months after mixing.

For a large job in the London area concrete made with aluminous cement is being used for certain work below ground level. The specified proportions for the concrete were 4 : 2 : 1, this being considered as rich a mix as desirable for such concrete in the particular work in question. Six-inch concrete cubes made upon the job without laboratory care, and representing without question the actual quality of material as deposited in the work, were crushed at an independent and responsible testing works and gave 5950 lbs. per square inch. The age of the cubes when tested was three days. According to the regulations, therefore, the permissible stress upon the concrete gave a figure, usually referred to as " the factor of safety," of 9·9.

In considering this question, it must be noted that the high crushing resistance of this concrete was due only to the cement used. It was not due to any unusual care in the choice of aggregates, grading, or mixing, which might have been held to be a variable factor, and, therefore, justifying the present limited stresses.

On the other hand, increases in the working stresses such as are usually assumed for designs outside the control of such regulations automatically necessitate greater reliance upon the care given to the work itself. On well-organised jobs, carried out by contractors experienced in this relatively new industry, such care is always given. Where proper attention is not given to the work, no regulations, however stringent, can in themselves produce first-class construction.

Regulations controlling building operations are admittedly framed to prevent bad work, whether this be due to dishonesty or incompetence, and unfortunately there appears to be greater scope for such contingencies with reinforced concrete than most other forms of construction. Notwithstanding this, however, there can be no justification for restricting the stresses upon a new and superior material about which there is ample practical evidence all over the country.

In passing, it may be stated that the allowable stresses to be taken should be estimated from actual " working " tests and not from those published by the manufacturers. This is no reflection upon these firms, for tests carried out by, or on behalf of, the manufacturers are laboratory tests, and the results represent the obtainable strength for the various concrete and mortar mixtures. The care taken in the selection, mixing, tamping, etc., however, is not, and cannot be, reproduced in actual construction, and the results for the " works " tests are therefore correspondingly lower. It is probable that the strength of the concrete in a properly supervised job is better than the " works " tests indicate, but not as strong as indicated by laboratory tests.

There is at present under construction in London a building entirely of reinforced concrete, the contract sum for which exceeds £500,000. In different parts of the job are being used ordinary Portland cement, rapid-hardening Portland cement, aluminous cement, and a brand of white cement, all in large quantities. A series of tests is being made, and some very useful information should be forthcoming regarding the comparative strengths and properties of concretes made from these cements, since the test pieces are being made and matured under precisely similar conditions and contain the same aggregates.

Peter Lind & Co.

We understand that the businesses of Messrs. Peter Lind & Co., the well-known firm of reinforced concrete designers and contractors, and Messrs. Saxild & Partners, will be amalgamated as from January, 1928, and will be known as Peter Lind & Co., Ltd. Messrs. Peter Lind & Co. were established in London in 1915, and have been responsible for the design and erection of a large number of important concrete structures. The business of Saxild & Partners was established by Mr. J. Saxild a few years ago, and specialises in marine work. The two firms are now co-operating in the £400,000 contract for the new Michelin Tyre factory at Stoke-on-Trent, which is rapidly nearing completion. Mr. Saxild is now in Turkey to supervise the construction of two new railways, with a total length of about 700 miles, and is expected to stay there for a year or two. The cost of this railway work is estimated at £10,000,000, and Messrs. Peter Lind & Co. have an interest in the contract.

Book Review.

"Bemessungsverfahren." By Prof. B. Löser.
Berlin: W. Ernst & Sohn. Price 6 R.M.

As its title reveals, this book is one of reference for engineers designing reinforced concrete work in accordance with the new German regulations of 1925. It is now in its second edition. In England there is no book in existence which deals in an exhaustive manner with design to any set of regulations.

Professor Löser has divided his work into nine parts, with an appendix dealing with the sectional areas, etc., of round bars. Part 1 is occupied with the determination of bending moments and shears for simple and continuous beams and frames with rigid joints. The question of the moments in columns of rigid frames is very thoroughly dealt with, and tables are supplied which will help the designer in carrying out the requirements of the regulations. It is noteworthy that the German rules, unlike those of the L.C.C., give definite information concerning the method of calculating column moments for varying ratios of beam to column slenderness. Professor Strassner's convenient diagram for the computation of the moment of inertia of tee-beams is reproduced. The tables for the determination of the pressure on walls of hoppers and silos are distinctly useful.

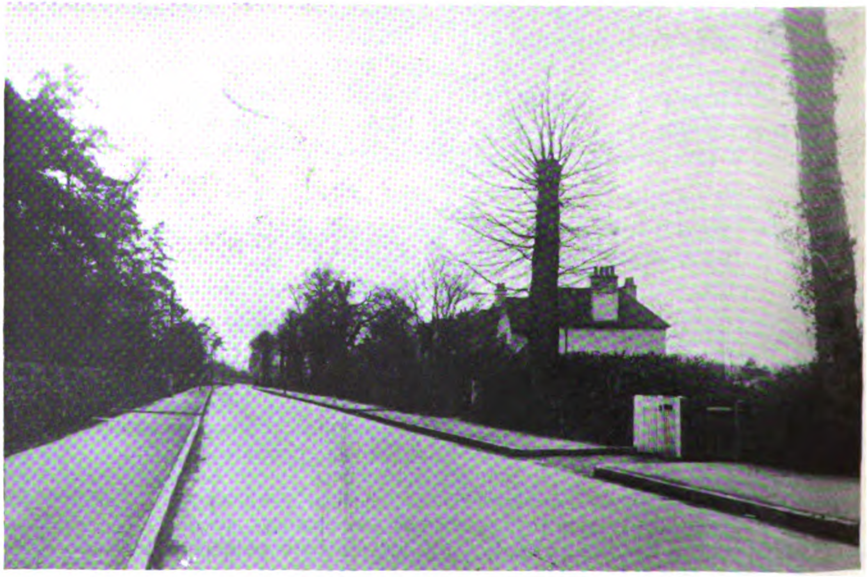
Part 2 deals with columns subjected to axial loading, both hooped and spiralled columns being included. It is interesting to observe the high stresses which are allowed when proper spirals are employed, more especially when we have read statements in English text-books derogatory to this type of column.

Bending and combined bending and compression or tension are treated in Parts 3 and 4. These are followed by articles on shear and adhesion stresses.

Slabs reinforced in one or two directions occupy Part 6, while flat-slabs are treated in Part 7 by the approximate methods which are more suitable for inclusion in regulations than the highly-complicated calculations entailed by the use of the Navier analysis.

Part 8 comprises the determination of stresses for given dimensions of members and given loads.

No less than 35 examples are fully worked out in Part 9. These should be of assistance to designers.—W. S. G.



Reinforced Concrete Road at Guildford.

[This concrete-surface road was completed recently, under the direction of Mr. W. G. Cross, then Borough Surveyor of Guildford. Mr. J. Douglas, of Southampton, was the contractor. The road is 6 in. thick, reinforced with B.R.C. mesh.]

Dingle Road Bridge, Bristol.

Dingle Road bridge, at Combe Dingle, Bristol, has been constructed for the purpose of carrying across the river Trym a new by-pass road from Westbury to Avonmouth. The river-bed is 28 ft. below the level of the adjoining land and the level of the crown of the new roadway.

The bridge is in reinforced concrete, the main dimensions being: Clear width between parapets, 40 ft.; span, 40 ft.; height of surface above mean river level, 25 ft.

The anticipated depth for foundations was 9 ft. below ground level. On opening down through a good sound marl, a sandy marl carrying water was found; as this was quite unsuitable for carrying weight, it was decided to excavate the whole area down to the gravel, which was found at a depth of 15 to 16 ft.

The extra depth was filled in with 8 to 1 mass concrete of limestone gauged from 2 in. to ¾ in., with large plums bedded therein and finished at the level of the underside of a 27-in. reinforced concrete slab. Tar roofing felt was laid over the wet and dirty bottom before depositing any concrete, and during the whole time of excavating and depositing steam pumping had to be maintained night and day.

The abutments are hollow, and are each 48 ft. long from the face of the abutment wall; the bottom consists of a reinforced concrete slab 48 ft. by 48 ft. by 2 ft. 3 in. thick, from which rise the abutment and wing walls tapering from 1 ft. 10½ in. thick at the base to 11 in. at the top under the deck beam. These walls are in turn supported by sloping counterforts 18 in. thick spreading to 13 ft. 6 in. at the bottom.

The reinforcement throughout consists of mild steel round bars, from 1⅛-in. to ½-in. diameter. The foundation slab is doubly reinforced, and splice-bars to walls and counterforts spring therefrom.

A plinth with 4½-in. projection is carried around all abutment walls. The wing walls are panelled by pilasters, which in turn have raised panels on which the surface has been fine-axed to show the stone aggregate and give variation to the surface. Simple mouldings are carried around the tops of the pilasters.

The span is composed of four parabolic arch ribs having a rise of 11 ft. 3 in. The thickness at the centre is 18 in., with depths of 2 ft. and 2 ft. 9 in. at the crown and springing respectively. There are eight bars at top and bottom of each. Upon the extrados of each arch rib are built up six 12 in. by 18 in. columns to carry deck beams. The reinforcement bars have helical hoops. These columns carry the main deck beams, 13½ in. deep; the two centre beams are 18 in. and the two side beams 17 in. wide; these are intersected by secondary beams 12 in. wide by similar depths.

The deck slab is 10½ in. deep, double reinforced with No. 9 and 8 B.R.C. fabric, except under footways which have No. 6 fabric. The deck slab has a fall of 1 in 40 longitudinally and is flat in cross section, the necessary camber being given by 4½-in. concrete laid thereon to proper contour.

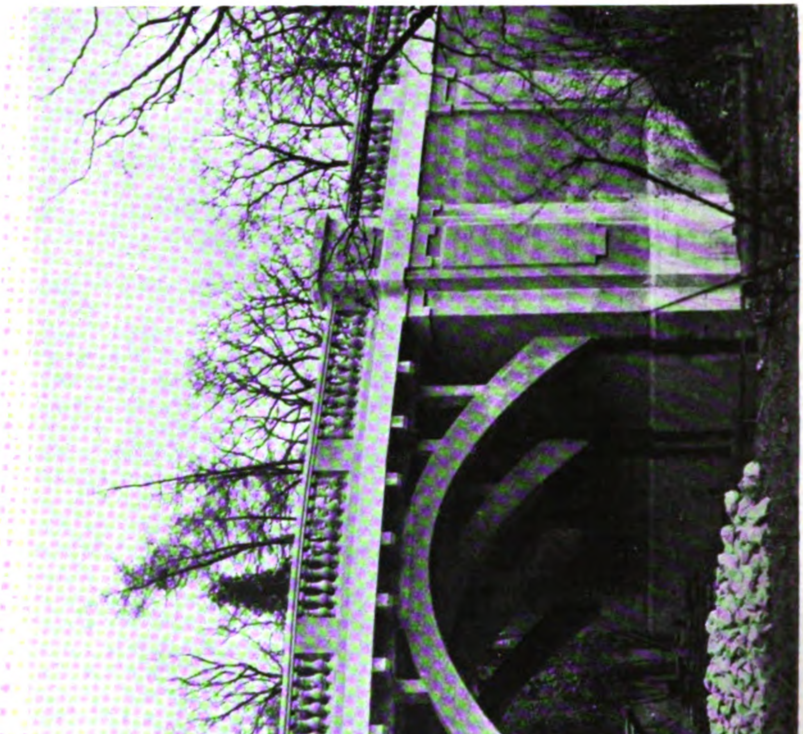
The cope beams carry a balustrade composed of pre-cast reinforced balusters, 9-in. diameter at 13-in. centres, surmounted by a 14 in. by 8 in. moulded coping, also pre-cast and reinforced. The balustrade is finished at ends and at abutment faces with reinforced moulded pillars 6 ft. 3 in. wide and intersected by intermediate pillars 2 ft. 10 in. wide over the abutment pilasters. Balusters have ⅞-in. bars through their centres, and these bars project into the cope beam and coping.

The kerbs to footways over the arch are of *in situ* concrete, 10 in. wide, the remainder being 5 in. by 14 in. Pennant edging.

Provision has been made through the abutments, and by brackets on the pillars of the bridge span, for gas, water and electric mains, which have been placed in position during construction.

The whole of the concrete in reinforced work has been composed of 6 to 1 granite concrete, the aggregate being Trevor granite graded from ¾ in. to ¼ in. mixed with Holm sand and limestone screenings 3/16 in. to dust. This last was added to give a clean face from moulds and proved very efficient, no stopping in having to be done on removal.

The shuttering for the pilasters was built up in not more than two lengths, the plain work between them being built up by raising the shuttering in 24-in.



Dingle Road Bridge, Bristol.

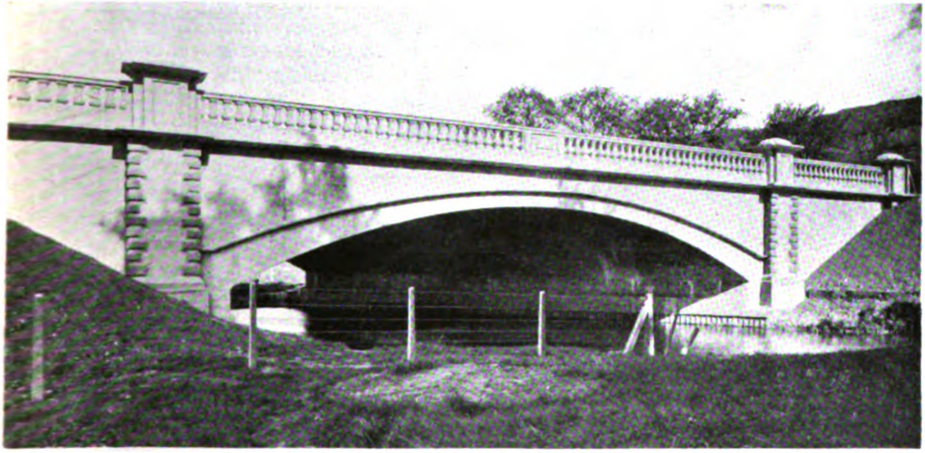
lifts. A uniform level was maintained each day in building walls and counterforts.

The whole of the concrete was measured dry through boxes, mixed in a machine of ⅓-cubic yard capacity, and passed by metal-lined chutes to the lower levels; that to upper levels was run in iron barrows from mixer to moulds. The whole of the labour was relief labour from the Employment Exchange, and practically all the men were new to the work.

New Dorking to Reigate Road.

THE last section of the new Dorking to Reigate road was formally opened last month by the Lord-Lieutenant of Surrey. This stretch is five miles long, and has a carriageway of 30 ft. and 8-ft. footpaths. It has been built at a cost of £143,000, including the construction of a reinforced concrete bridge over the river Mole. The road is of reinforced concrete, without surfacing, and is built on the principle adopted on the most recent all-concrete roads in Surrey. The work was carried out by direct labour, under the direction and to the design of Mr. W. P. Robinson, B.Sc., A.M.Inst.C.E., County Surveyor of Surrey.

The road has a total thickness of 8 in., laid in two courses. The bottom layer, 6 in. thick, is of 1 : 2 : 4 concrete. The sand for this course is graded so that 55 per cent. passes a 10-mesh sieve, and is rejected by a 30-mesh; 30 per cent. passes a 30-mesh and is rejected by an 80-mesh; and 15 per cent. passes an 80-mesh and is rejected by a 100-mesh. The coarse aggregate of the lower course is graded so that 60 per cent. passes a 1-in. ring and is rejected by a ½-in. ring; 40 per cent. passes ½-in. and is rejected by ⅛-in. The coarse material is crushed and washed. The sand is silica sand from the Buckland pits. The top course is 2 in. thick, and is of a 1 : 1½ : 3½ mix. The coarse and fine aggregate are graded in the same manner as for the lower course. The coarse material for the bottom course is pit gravel; for the top course the coarse material is partly shingle and partly granite chippings. Buckland silica sand is used for the top as well as the lower course.



Deepdene Bridge.

Careful supervision is exercised over all the operations of mixing and placing. The water content is carefully controlled, and no sloppy mixes are allowed; as a rule the water content is 10 or 12 gallons per cubic yard of concrete. This control of water content is believed to be one of the factors in the success of the reinforced concrete roads already laid in Surrey under Mr. Robinson's direction.

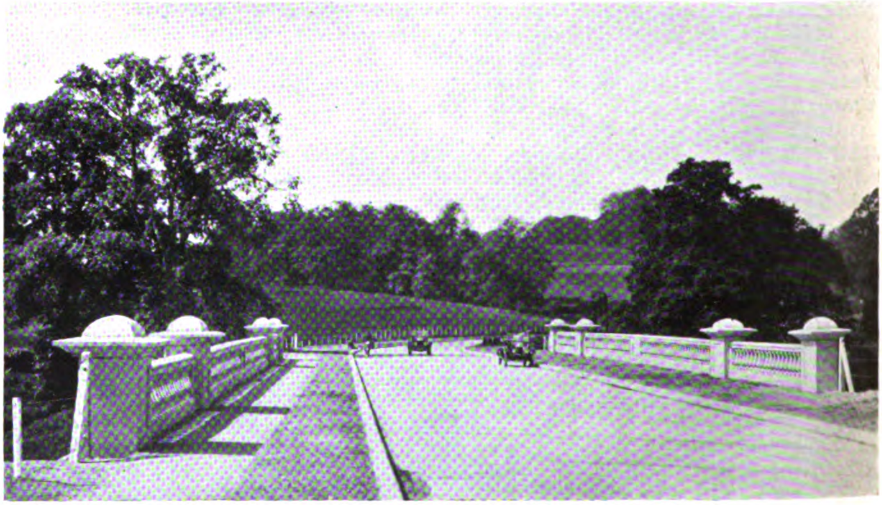
Expansion joints are placed at intervals of 14 ft., at an angle of 60 degrees to the kerb. The alternate bay system is used for placing the concrete, the intermediate bays being filled fourteen days after the first.

The reinforcement varies according to the nature of the subsoil; both B.R.C. mesh and Walker-Weston double-layer are used, as well as a system of plain steel bars. Where two layers of reinforcement are used, they are placed 1½ in. from the top and bottom surfaces respectively.

Mechanical mixers with distributing booms were used almost exclusively, and the surface finished by hand-tamping with special beaters. The surface was allowed 28 days to harden, during which period it was kept covered with 3 in. of damp sand frequently sprinkled.

An interesting new departure is the laying of the reinforced concrete direct on filling at the approaches to the bridge. The usual practice on made ground is to build a macadam road first, and place the concrete on this after it has been in use for a year or two to allow any settlement to take place.

Deepdene Bridge has been built entirely in reinforced concrete by direct labour. It has a span of 70 ft. Its position in the midst of one of Surrey's beauty spots caused considerable attention to be given to the design, and also to the surface colour and texture of the concrete. The colour adopted is a sand-yellow on all exposed surfaces, so that the colour of the bridge is the same as the sandy soil of the district. The effect was obtained by the use of coloured Portland cement and a silica-sand aggregate. The whole of the parapet work was pre-cast on the site in wood moulds by direct labour.



The New Reigate-Dorking All-Concrete Road and Deepdene Bridge.

Concrete Roads: Faults and their Lessons.

By R. A. B. SMITH, A.C.G.I., A.M.Inst.C.E.

1.—DESIGN.

ALTHOUGH cement was used in Scotland in road work so far back as 1865, and there are examples in Edinburgh to-day of roads built in 1872–3, these are not concrete roads as we know them, but are rather what we would call "grouted cement roads." We have to cross the Atlantic to see the first concrete road constructed on more modern lines and this is in Maine Street, Bellefontaine, Ohio. The first portion of this road was constructed in 1892, and consisted of a strip 10 ft. wide by 220 ft. long. This was followed by the concreting of the Courthouse Square in the same town in 1893–4. It is interesting to note that this was a two-course road, the base consisting of 1 part of cement to 3 parts of gravel and 4 in. thick, and the top of 1 part of cement to 2 parts of fine aggregate passing a screen having 3 meshes to the inch, and 2 in. thick. Both courses were hand tamped, and the concrete was only wet enough to allow moisture to come to the surface when tamped.

It was not until 1912 that any complete concrete road was constructed in Great Britain, when Mr. Matthews Jones designed and constructed Roberts Lane, Chester. This road was laid in one course consisting of broken granite and sand; the proportions were 5 of mixed aggregate to 1 of cement, and the thickness 7 in. Other roads over ten years old are: Canmore Street, Dunfermline, which was laid in two courses, the bottom 4 in. consisting of 3 parts Whinstone, 2 parts sand, and 1 part cement, and the top 2 in. of 2 parts Whinstone chippings, 2 parts fine granite and 1 part cement. Tilbury Dock Road, laid in 1917, was 7 in. thick, with a 5½-in. bottom course and a top course of granite chippings, sand and cement. The reinforcement in the case of Roberts Lane was placed 2½ in. from the bottom; in the case of Canmore Street it was 2 in. from the bottom; and in the case of the Tilbury Dock Road it was 1½ in. from the top.

The Courthouse Square, Bellefontaine, was constructed in a series of small panels, while the first concrete roads in Great Britain were constructed without any allowance for expansion or contraction. In spite of the fact that until quite recently no endeavour has been made to understand the underlying principles of concrete road design, these early examples have stood up very well to traffic conditions which have very much changed since the time when they were constructed.

Although the alterations in design would not be obvious to the layman, to the engineer they have been very varied and of the utmost importance. It must be remembered that these early roads were nearly

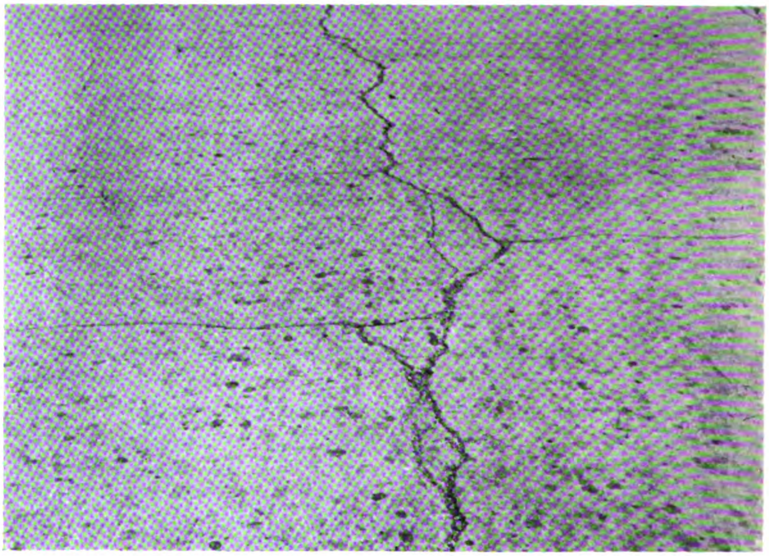


FIG. 1.—SHOWING NATURE OF CRACKS IN CONTINUOUS ROAD, DUE TO USING THIS TYPE OF CONSTRUCTION IN UNSHELTERED POSITION.

always covered with a thin coating of tar spray and chippings, and for several years this was an annual maintenance cost. When, later on, engineers, like Mr. Arthur Harrison, Borough Surveyor of Southwark, constructed concrete roads and left the surface exposed it was realised that concrete could function in an even more important way than it had hitherto done. It was this exposure of the surface which made engineers more interested in the problem of overcoming certain difficulties which presented themselves. It was found that different materials had very different wearing qualities ; that the movement of the concrete varied in different positions ; that cracks appeared in some roads and not in others ; and it became of importance to discover exactly what all these apparent vagaries really meant.

Thickness of Slab.

All the early roads in Great Britain were 6 to 7 in. thick, and it is difficult to understand why no thinner roads were tried unless it was the innate caution which is an English characteristic. If we wish to know anything of thinner construction we have to go to the State of California. For a number of years this State constructed roads with a concrete slab only 4 in. thick with a mix of 5 : 2½ : 1. In 1917 the richness of the mix was increased to 4 : 2 : 1. In 1920 the thickness was increased to 5 in., and later to 6 in. The original object of the 4-in. slab was that it should be used eventually as a base, but that it would be used as a running surface until such time as the wearing surface showed signs of disintegration and it appeared necessary to resurface it. The thin slab, however, did not prove a success, and with a great increase in traffic it was soon found necessary to place another 4 in. of reinforced concrete on top of the existing 4 in.

Other experiments have been made with thicknesses of 4 in., but so far they have not met with outstanding success. We may therefore take it that a minimum thickness of 6 in. of concrete is desirable in order to give the slab sufficient sectional area to stand the stresses set up by temperature changes, etc., over a period of years.

There is one other important factor which has to be considered before one can finally decide on the thickness of the slab necessary, namely, the type of traffic that is to be expected on the surface. Where the road carries only light traffic, and only an occasional lorry is expected, a 6-in. slab will suffice, although many engineers prefer a minimum of 7 in. in order to allow for irregularities in the sub-base which it is impossible to eradicate at a reasonable cost. Where the traffic is medium with a fair number of lorries or 'bus services it seems advisable to add an inch to the thickness, and where the traffic is distinctly heavy both in volume and in weight then the thickness of the slab should be 8 or 9 in.

Slabs Thickened at Sides or Centre.

The Bates Experimental Road at Springfield, Illinois, was composed of 63 sections of road which included all the well-known types. It is only the intention of the author, however, to discuss the results of those tests that were carried out on the concrete lengths. As a result of this experimental road, it was laid down that it was advisable to keep the slab of minimum thickness up to within 2 or 3 ft. of each edge, and that the slab should then be thickened so that the depth at the edge measured from 2 to 3 in. more than the depth at the centre. The maximum weight allowed in the United States on one wheel is 9,000 lbs., and the formula deduced for the strength of a corner was that d should equal $\sqrt{\frac{3W}{s}}$, where d is the required thickness of pavement at unsupported edge, W is the maximum load expected on one wheel, and s is one-half of the modulus of rupture of the concrete to be used. Assuming the modulus of rupture to be 600 lbs. per sq. in., the required depth would be 9·5 in., and assuming 800 lbs. the required depth would be 8·2 in.

At first sight it is surprising that the result of this very important

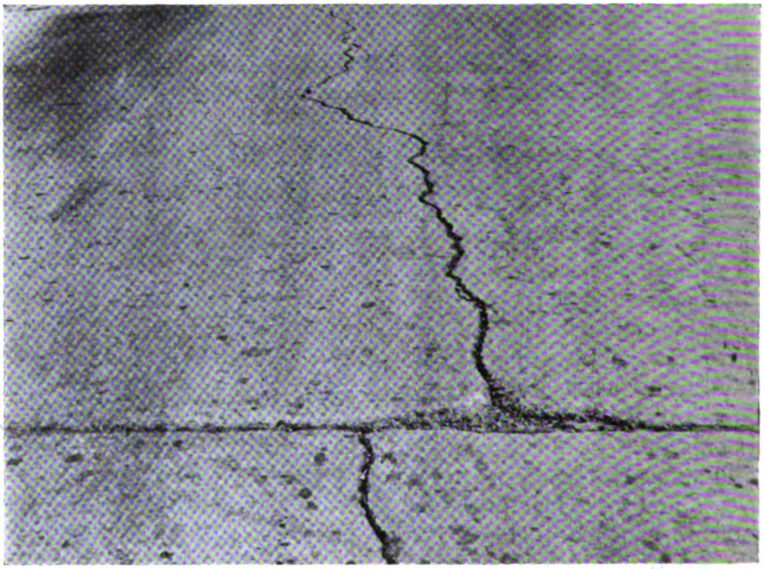


FIG. 2.—SHOWING NATURE OF CRACKS IN WIDE ROAD WITH EXPANSION JOINTS ONLY; DEMONSTRATING THE NECESSITY FOR FURTHER DIVISION OF THE SLAB.

test has not had any appreciable effect upon the design of concrete roads in this country so far as the thickening of edges is concerned. It would be difficult to state an instance in Great Britain where the thickness of the concrete at the centre is less than that at the sides. The author is certainly not aware of such a case. One of the great points brought out in the test was that the maximum danger occurs when the outer lorry wheels are within 2 ft. to 2 ft. 6 in. of the edge of the slab. In Great Britain there are many concrete roads on which the average lorry certainly runs with its outside wheels in such a position, but so far there is no instance where appreciable damage has been done to the slab for that reason.

We suffer very little from corner breaks or breaking at edges; the main troubles are longitudinal and transverse cracking and breaks at joints. In the presence of this evidence the average English engineer confined himself to constructing concrete roads with the same thickness at the centre as at the sides. But there is a school of thought that considers very strongly that the thickness of the slab should be greater at the centre than at the edges, which is absolutely contrary to the results of the Bates Test. The argument used by this school is that when concrete expands on a camber it tends to move out to the sides of the road and in consequence when contraction takes place it finds some difficulty in climbing up the slope formed by the camber. Therefore, there is a tendency for the road to crack longitudinally, or, if there is a centre joint, for that joint to become wider and wider. It is certainly true that roads of fair width do eventually crack longitudinally within a foot or two of the centre line. It is equally true that by using sufficient reinforcement and sufficiently thick concrete in the centre these cracks can be avoided, but inasmuch as 6 in. is about as thin as the edge can be it means that all roads would be at least 9 in. thick in the centre.

A little closer investigation into the action that takes place in concrete throughout the year shows that there is a tendency for the slab, whatever span it may be, to arch itself under heat conditions. When the rays of the sun are directly on the road surface the top portion must be heated more intensely than the bottom, with the result that the expansion would be greater at the top than at the bottom. This gives rise to the arching effect which has been mentioned.

It is obvious that so far as the upper layer is concerned we are now introducing stresses into it which bring the concrete into tension. In consequence, there is a grave risk of a crack occurring at the top of the concrete in the centre of the arch due to the tearing of the concrete, and this danger is increased when traffic is travelling over the arch as the vibration of the loads must put additional stresses on the surface concrete. The crack having occurred in the top, it is naturally not long before it penetrates to the bottom. It is, therefore, a question for the engineer to decide whether to increase the thickness of the concrete to such an extent, or supply sufficient reinforcement to prevent this crack taking place, or alternatively, to construct this crack as a central joint, or to allow it to occur and pay due attention to it during the ordinary course of maintenance. From a first cost point of view it is most economical to construct the slabs the same thickness at the centre as at the side.

As a matter of interest a number of sections are shown in *Fig.* 4 which have been arrived at after a good deal of experience by various States in America.

Theoretically it should be possible to design and construct a slab of indefinite length and width which, when properly reinforced, and having sufficient depth of concrete, will not show any definite cracks. However, in practice these cracks do occur, and though they may be invisible in the first instance, they gradually develop and after a period ravelling commences. If a road is to be constructed for purely utilitarian purposes and is to be put down at the minimum expense possible, continuous construction might easily be accepted as the form which most nearly fills the bill. But anyone undertaking this work must realise that he will have annually to fill a number of cracks, especially when

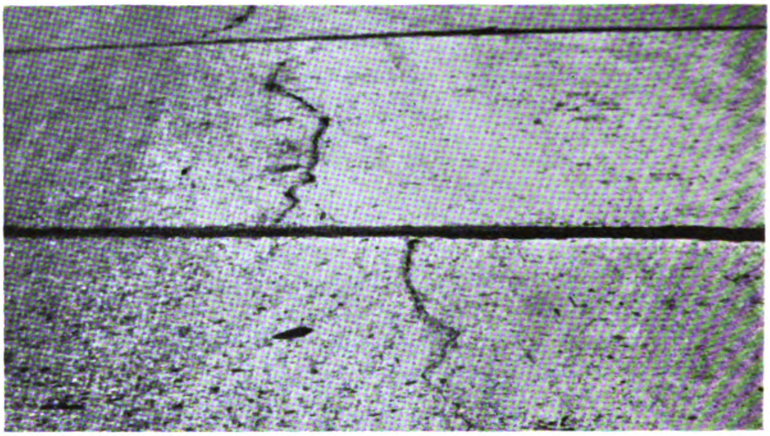


FIG. 3.—SHOWING NATURE OF CRACKS IN ALTERNATE-BAY CONSTRUCTION: THESE CRACKS HAVE ALWAYS OCCURRED AT RIGHT-ANGLES TO THE JOINT BETWEEN BAYS, WHETHER THE JOINT IS AT RIGHT-ANGLES TO THE KERB OR NOT, BUT MAY BE PREVENTED.

they start ravelling. Unfortunately there is at present no filler on the market the colour of which is the same as a concrete road ; in consequence, these irregular cracks are filled with black filler and are not at all an attractive sight—to the layman, at first sight, they rather give the impression that the road is breaking up.

Continuous Construction.

There are in America roads of continuous construction fourteen years old which are in an excellent state of preservation. These roads have become so stained with oil droppings that the cracks when treated with bitumen and tar are unnoticeable. There is, however, one definite disadvantage of continuous construction which is of more importance to us in Great Britain than in the United States, and that is that in long spells of very hot weather the roads thus constructed burst at intervals. It may be only one in a year or two, but there is a considerable and unexpected hindrance to traffic which may prove very dangerous and is certainly objectionable. It is not always possible in Great Britain to do as they do in the United States, namely, run the car round the burst in the neighbouring fields. These bursts have only occurred in England on the more exposed roads, such as the North Circular Road and the New Cambridge Road, and they have not occurred in Liverpool, Middlesbrough, and other places where the roads are well protected.

Even if these bursts have not actually taken place the shape of the road has been lost. Canmore Street, Dunfermline, has already been mentioned as a good example of a continuously constructed road, as is

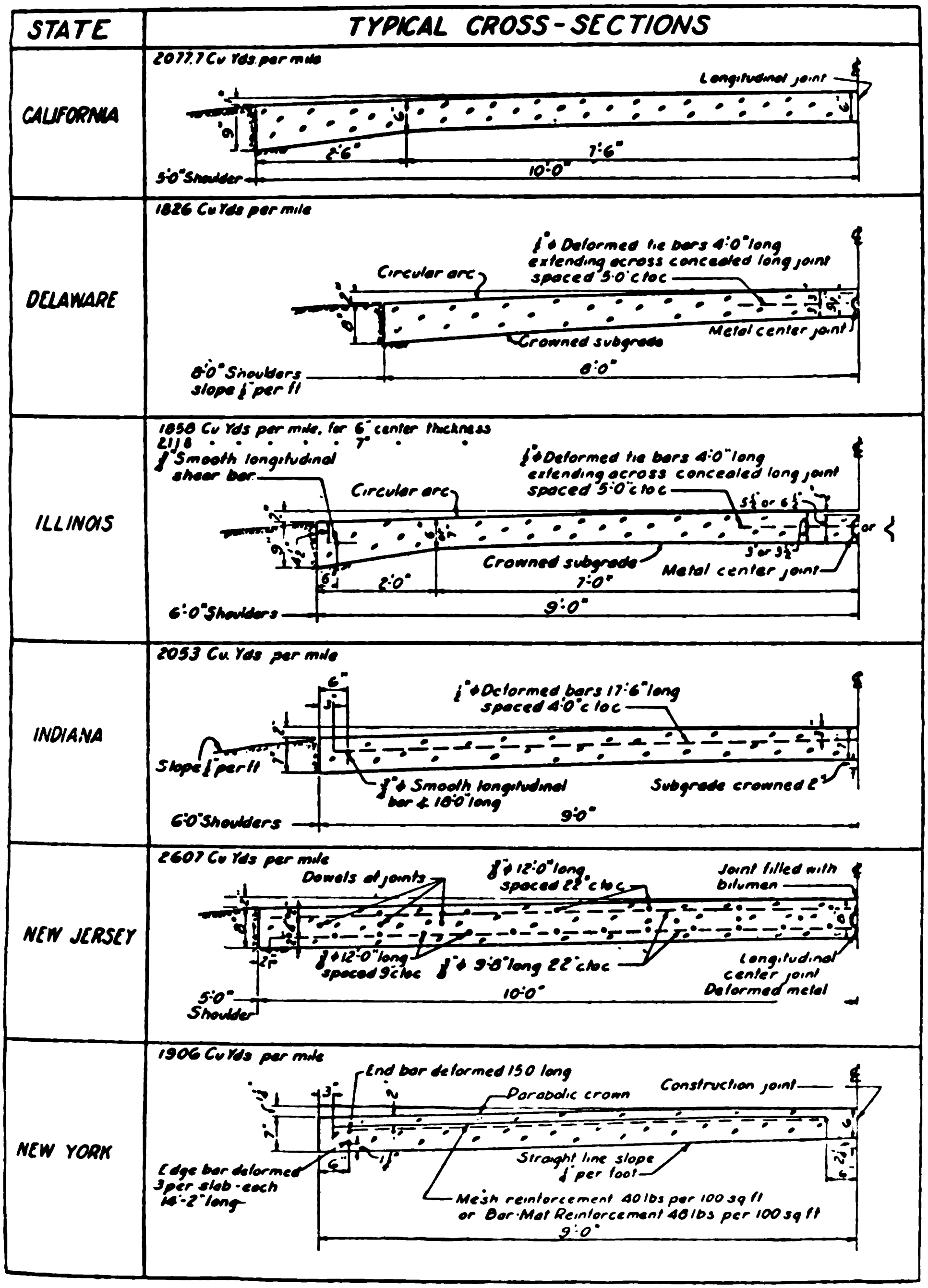

STATE
TYPICAL CROSS-SECTIONS
CALIFORNIA
2077.7 Cu Yds per mile
Longitudinal joint
9"
2'6"
7'6"
10'0"
5'0" Shoulder
DELAWARE
1826 Cu Yds per mile
½" ⌀ Deformed tie bars 4'0" long extending across concealed long joint spaced 5'0" c to c
Circular arc
Crowned subgrade
Metal center joint
8'0" Shoulders slope ½" per ft
8'0"
ILLINOIS
1858 Cu Yds per mile, for 6" center thickness
2118 " " " " " 7" " "
½" Smooth longitudinal shear bar
½" ⌀ Deformed tie bars 4'0" long extending across concealed long joint spaced 5'0" c to c
Circular arc
5½ or 6½"
5 or 5½"
or
Crowned subgrade
Metal center joint
6"
2'0"
7'0"
6'0" Shoulders
9'0"
INDIANA
2053 Cu. Yds per mile
6"
½" ⌀ Deformed bars 17'6" long spaced 4'0" c to c
Slope ½" per ft
½" ⌀ Smooth longitudinal bar ℄ 18'0" long
Subgrade crowned ℄
6'0" Shoulders
9'0"
NEW JERSEY
2607 Cu Yds per mile
Dowels at joints
½" ⌀ 12'0" long, spaced 22" c to c
Joint filled with bitumen
½" ⌀ 12'0" long spaced 9" c to c
½" ⌀ 9'8" long 22" c to c
Longitudinal center joint Deformed metal
2'
5'0" Shoulder
10'0"
NEW YORK
1906 Cu Yds per mile
End bar deformed 15'0" long
Parabolic crown
Construction joint
3"
Edge bar deformed 3 per slab - each 14'-2" long
6"
Straight line slope ½" per foot
Mesh reinforcement 40 lbs per 100 sq ft or Bar-Mat Reinforcement 40 lbs per 100 sq ft
9'0"

FIG. 4.—TYPICAL SECTIONS SHOWING ROAD SLABS THICKENED AT THE SIDES.

the Southampton Dock Road, and there are several good examples in the Irish Free State. It will be seen, therefore, that continuous construction can reasonably be undertaken in very sheltered streets and in certain cities where the variation of temperature is very small.

Alternate Bay Construction.

Reports of these bursts led engineers to seek to avoid this trouble, and the alternate bay method of construction was adopted by such engineers as Mr. J. B. L. Meek, City Engineer of Manchester, Mr. W. P. Robinson, County Engineer of Surrey, and others. The method employed is as follows: A strip of concrete is laid across the road, the width varying from 6 to 24 ft. according to the engineer's ideas on the subject. A space equivalent to the width of one bay is then left, and another strip is laid to the same dimensions. Alternate bays are thus constructed right to the end of the work, and then, working backwards, the intermediate bays are filled in (*Fig.* 5).

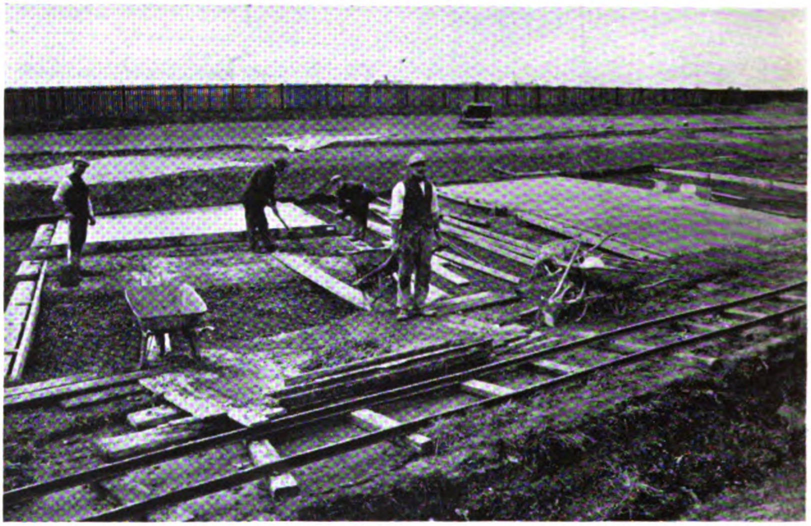


FIG. 5.—MODERN ALTERNATE-BAY CONSTRUCTION.

Generally speaking, engineers specify that not less than ten days should be allowed to elapse before the intermediate bays are laid, to allow the initial contraction to take place in the first-laid bays. Some engineers have gone to the extent of making the first-laid bays wider than the intermediate with the object of reducing the size of the crack due to the contraction of the intermediate bay when setting. This seemed to do away satisfactorily with the question of bursts, although there has been one inexplicable case in the Manchester area and an inexplicable one in Yorkshire.

The advantages of this method are that the screed is not too long, that one is able to use the alternate bays so soon as they have hardened for either mixing or depositing materials, and it is easy to obtain a perfect camber across the road. The disadvantages are the number of joints introduced and the difficulty of getting the intermediate bays exactly the same level as the alternate bays. Another argument in favour of alternate bay construction is that by laying the concrete in bays across the road it has complete freedom to expand or contract towards either side. Another point noticeable in a clay sub-base is that the level of the sub-base is gradually raised in the intermediate bays until such time as the concrete is deposited ; it is very necessary therefore to check this level to ensure a proper depth of concrete.

There seems to be an impression among some engineers that the expansion of concrete along its breadth may be neglected provided there is sufficient freedom along its length. This, of course, is not the case. It is true, however, that if the length is three times the breadth the amount of expansion in the direction of the length is three times the expansion in the direction of the breadth. In consequence, by laying the road in a series of panels, it is possible to build a road with a series of breathing spaces at short intervals with the result that expansion across the breadth of each panel is not sufficient more than to tighten the joint.

Some engineers prefer to lay these strips at an angle instead of straight across the road, one of the objects being to prevent a lorry bumping with both wheels at the same time from one slab to another. It still remains to be proved, however, whether there is any advantage in this method. It is certainly more difficult to obtain good screeding.

It was thought that by adopting alternate bay construction the longitudinal crack would not occur down the centre of the road. It certainly does not always occur as one continuous crack through all the panels, but each bay forms its own crack within a few feet of either side of the centre, but generally at right angles to the joints (*Fig* 3).

(*To be continued.*)

Summer Evening Courses.

THE Manchester Municipal School of Technology has issued a prospectus of a series of evening classes and lectures to be held from June 13 to July 26 this year. The classes cover all engineering and kindred subjects, including Building. The building classes include lectures and laboratory work on the preparation and mixing of concrete, including cement manufacture, testing of concrete, the cement water-ratio method of controlling strength, choice and grading of aggregates, etc., and comparisons of the properties of rapid-hardening cements compared with ordinary Portland cement. Other subjects are steelwork specifications and the structural design of overhead electric transmission lines of timber, steel, and reinforced concrete. Professor F. E. Drury is the Head of the Building Department.

Reinforced Concrete Water Tanks.

Tanks below Ground Level.

By LESLIE TURNER, B.Sc., A.M.Inst.C.E.

ANY tank where the ground line occurs more than 1 ft. above the level of the floor, or where earth or filling is to be tipped against the outside of the walls, will be termed, and must be treated as, an underground tank. It will be readily appreciated that this introduces another condition into the design, namely, the walls must act as retaining walls when the tank is empty in addition to holding the water when full.

In the following design it is assumed that the ground is not waterlogged. Should the latter be found to be the case a special heavier

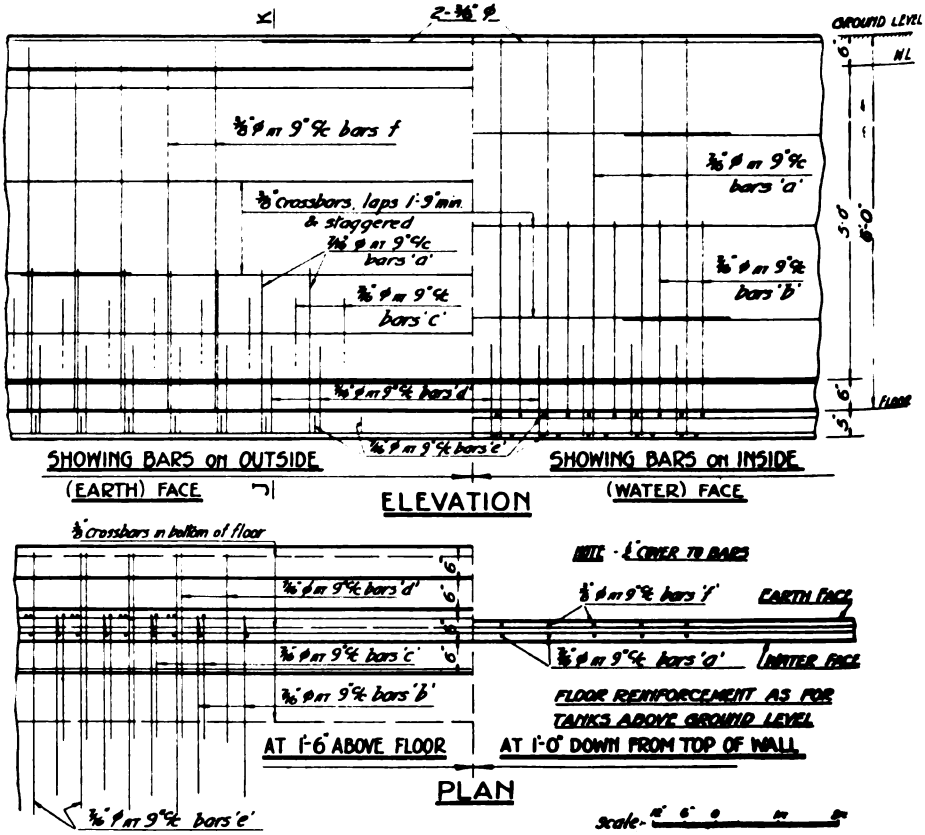

2-¾" φ
GROUND LEVEL
6"
WL
⅜" φ AT 9" c/c bars f
7/16" φ AT 9" c/c bars 'a'
⅜" crossbars, laps 1'-9" min. & staggered
7/16" φ AT 9" c/c bars 'a'
7/16" φ AT 9" c/c bars 'b'
7/16" φ AT 9" c/c bars 'c'
5'-6"
6'-0"
FLOOR
6"
5"
7/16" φ AT 9" c/c bars 'd'
7/16" φ AT 9" c/c bars 'e'
SHOWING BARS ON OUTSIDE (EARTH) FACE
ELEVATION
SHOWING BARS ON INSIDE (WATER) FACE
⅜" crossbars in bottom of floor
NOTE - 1" COVER TO BARS
6"
7/16" φ AT 9" c/c bars 'd'
7/16" φ AT 9" c/c bars 'c'
7/16" φ AT 9" c/c bars 'b'
⅜" φ AT 9" c/c bars 'f'
EARTH FACE
7/16" φ AT 9" c/c bars 'a'
WATER FACE
FLOOR REINFORCEMENT AS FOR TANKS ABOVE GROUND LEVEL
AT 1'-6" ABOVE FLOOR
AT 1'-0" DOWN FROM TOP OF WALL
PLAN
7/16" φ AT 9" c/c bars 'e'
Scale

FIG. 1.

design would be required, otherwise the floor may blow in or the whole tank float and rise bodily in the ground, a not uncommon occurrence.

Reference should be made to "C. & C.E.," May, 1927, where preliminary remarks and a description of the floor are given for tanks above ground level; these also apply to the design for underground tanks.

The notes on page 316 regarding the construction of the wall given again apply here, except that the reinforcement is different as will be seen from *Figs.* 1 and 2, which give full details. It will be noted that the concrete sizes are the same as before, while it must be understood that the additional corner reinforcement shown on plan E, *Fig.* 1, page 314, must, of course, be inserted in the manner there described.

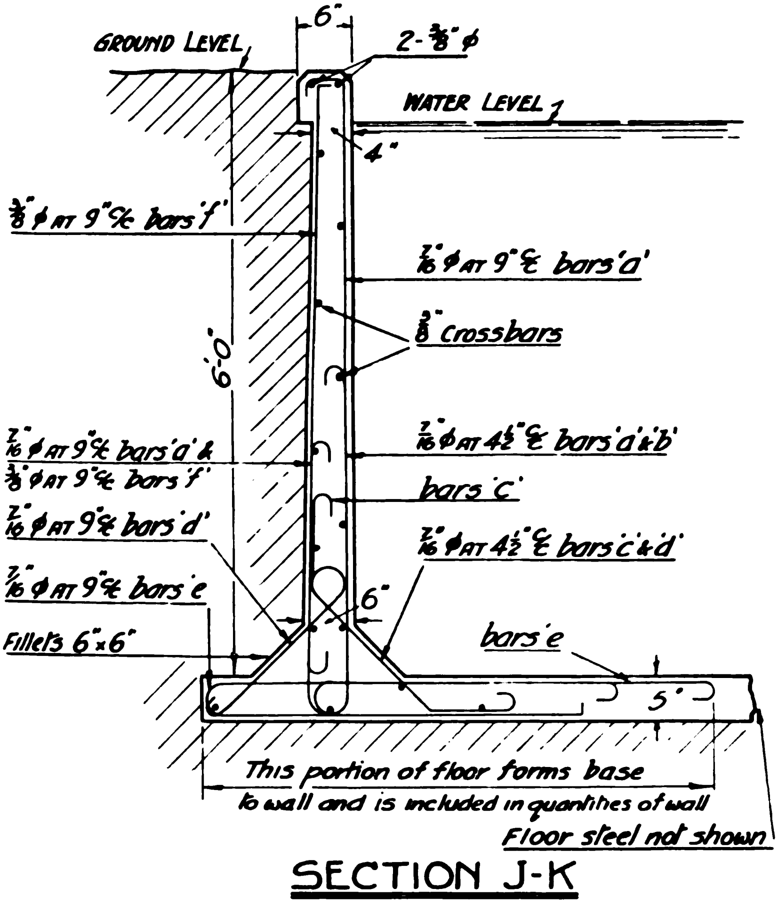

6"
GROUND LEVEL
2-3/8" ϕ
WATER LEVEL
4"
3/8" ϕ AT 9" c/c bars 'f'
7/16" ϕ AT 9" c/c bars 'a'
3/8" crossbars
6'-0"
7/16" ϕ AT 4½" c/c bars 'a' & 'b'
7/16" ϕ AT 9" c/c bars 'a' &
3/8" ϕ AT 9" c/c bars 'f'
bars 'c'
7/16" ϕ AT 9" c/c bars 'd'
7/16" ϕ AT 4½" c/c bars 'c' & 'd'
7/16" ϕ AT 9" c/c bars 'e'
6"
Fillets 6"×6"
bars 'e'
5'
This portion of floor forms base to wall and is included in quantities of wall
Floor steel not shown
SECTION J-K

FIG. 2.

Quantities.

As in the preceding case the quantities are given here :—

(1) per square yard of floor (excluding wall base)

(2) per lineal yard of wall (including wall base).

FLOOR (*per yard super*) :—

Shuttering—5-in. board round perimeter, staked.

Concrete—9 sq. ft., 5 in. thick . . . . 3·75 cu. ft.

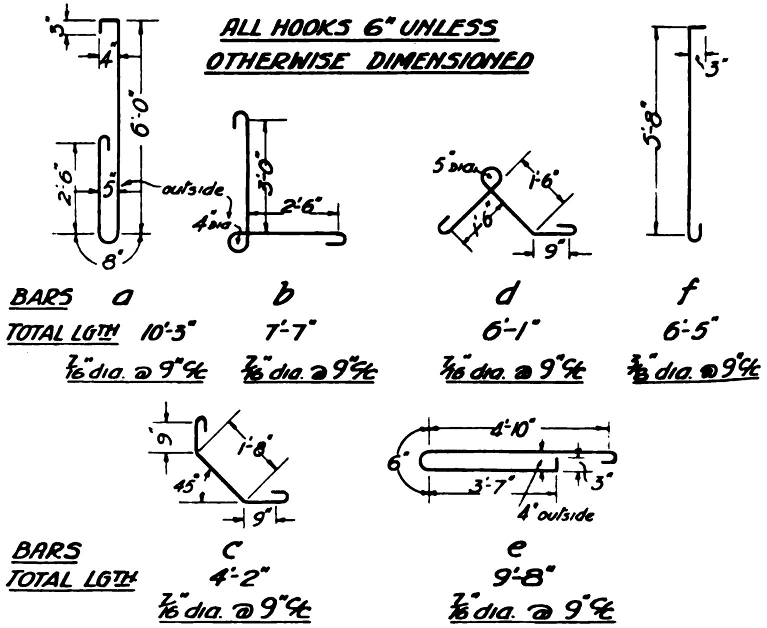
Reinforcement—⅜-in. bars at 18-in. centres, both ways, in top and bottom, straight, including a reasonable amount for laps . 10 lbs.

WALL (*per lineal yard*) :—

Shuttering—38 ft. super (both sides measured). Add for posts, struts and cutting.

			cu. ft.
Concrete—	Wall base (or floor),	15 sq. ft., 5 in. thick .	6·25
	Fillets . .	6 lin. ft., 6 in. by 6 in. .	0·75
	Wall . .	18 sq. ft., 5 in. av. . .	7·50
	Coping . .	3 lin. ft., 6 in. by 2 in. .	·25
			14·75

Reinforcement—approx. 106 lbs.



CROSSBARS—15 ⅜-IN. DIAMETER BARS OF LONGEST CONVENIENT UNIT LENGTH. ADD 2 FT. FOR LAPS AND ARRANGE LAPS TO BE STAGGERED.

The notes relating to the mix of the concrete and the care in the filling of the tank given on pp. 317 and 318 apply equally in this case. In addition the earth filling or tip must not be thrown against the wall and tamped until five or six weeks have elapsed (assuming ordinary Portland cement is used).

With regard to the vertical bars in this wall, it will be seen that on both earth and water faces these bars occur nearest the surface (each having ½-in. cover of concrete) so that the crossbars lie inside in both meshes.

This design would admit of the tank being tested by filling with water before the earth bank is filled in around it ; again, at any subsequent date the earth bank may be removed for short lengths, if necessary down to within, say, 2 ft. of the bottom, without emptying the tank.

Modifications for Smaller Tanks.

The following modifications for lesser depths and for short-sided tanks apply to tanks both above and below ground level.

Modifications for Lesser Depths.—Should the maximum depth required be 4 ft. or under, the thickness of the wall may be reduced to 4½ in. and the diameter of the bars reduced to ⅜ in. The lengths of the latter must, of course, be shortened to suit, leaving a clearance or cover of ½ in. at the top and bottom. The radius of the circular bend in the fillet bars must also be reduced to 3½ in. The thickness of the floor may be reduced to 4½ in. if the ground is reliable.

Modification for Tanks of less than 6-ft. Side.—If any two opposite walls of a tank 6 ft. deep are to be built closer than 6 ft., as in the case of a tank 5 ft. 6 in. square on plan, then the floor must be 6 in. thick throughout, and the top layer of floor reinforcement increased to ½-in. diameter, hooked both ends and placed at 9-in. centres. Where the depth of water is about 4 ft. or less the original 5-in. depth may be retained.

Reinforced Concrete in Panama.

THE British Vice-Consul at Panama reports that the construction of a large number of reinforced concrete buildings is contemplated in that city, and he accordingly suggests that British firms interested in the supply of materials used in this class of construction should forward catalogues, prices, etc., of their products for transmission to the leading local contractors. Four copies of catalogues, etc., he states, could be advantageously placed, and these should be addressed direct to H.M. Consul-General, British Consulate-General, Panama City.

The Vice-Consul has also furnished some particulars regarding the following schemes which are about to be undertaken in Panama, and which may possibly provide openings for the supply of British materials, etc.

(1) The construction of a bath house at Panama City, by a firm of local contractors, at an estimated cost of 16,000 dollars.

(2) The erection of a first-class modern hotel to cater for tourist traffic. The building is to be of reinforced concrete, and will cost not less than 50,000 dollars.

Firms in a position to offer materials of British manufacture can obtain further particulars of these projects, on application to the Department of Overseas Trade, 35 Old Queen Street, London, S.W.1.

Questions and Answers relating to Reinforced Concrete.

Readers are cordially invited to send in questions relating to concrete. These questions will be replied to by an expert, and, as far as possible, answered at once direct and subsequently published where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—Ed.

Roof for Tank.

Question.—I have a water tank 37 ft. 4 in. inside diameter which I wish to cover over. In the centre is a tower 5 ft. outside diameter, left open, so that the annular space between the tower and the outer walls only is to be roofed.

What kind of roof would you suggest; no snow falls here, so that as far as this item is concerned the roof may be flat. I would like to avoid intermediate supports between the outer and inner circle, if possible without incurring unnecessary expense.

Would a flat roof supported on the outer wall and a bracket on the tower be simpler than the most direct way of dividing the space in sectors by main beams and then spanning the intermediate space by slabs so as to form the usual T beams? How should the armouring of the cantilever member round the tower be disposed so as to support the free end of the annular ring? Will it be on the principle of mushroom construction?

L. Gate.

Malta.

Answer.—The roof could be constructed as suggested, though there is no object in having a slab above the cantilever. It would be better constructed monolithic with a concealed point of contraflecture.

Anyone experienced in reinforced concrete design would have no difficulty in designing either a cantilever or a slab, and if you have no experience in this type of construction you would do well either to adopt generous dimensions for the concrete and reinforcement, or obtain professional advice.—O. F.

Tank for Creosote.

Question.—In connection with the design of an underground storage tank for creosote oil, perhaps you could tell me whether such a tank could be constructed in mass concrete, keeping in view any deleterious effect which the oil might have on the concrete. If this material is suitable would any special waterproofing substance be required, or could the tank be made watertight by any special means, such as a rich mixture on the face.

J. S. Marshall.

Edinburgh.

Answer.—A concrete underground tank would be quite suitable for creosote. The inner 3 in. should not be less rich in cement than, say, 1 : 1½ : 3, and should be mixed a little wetter than might be correct for a tank not having to carry creosote. We do not think that any surface treatment would be either effective or necessary. Obviously special precautions must be taken between successive day's concreting to prevent any contraction or construction cracks, definite rebated joints being left in all cases and special care taken with the chipping and grouting previous to depositing fresh work.—O. F.

Concrete Road in Channel Islands.—The first section of concrete road to be laid in the Channel Islands has just been carried out by direct labour at St. Helier Harbour under the supervision of the States Engineer, Mr. E. Berteau. It is reinforced with B.R.C. Fabric.

Cement Marketing Co., Ltd.—Mr. James Stevens, who has been connected with The Associated Portland Cement Manufacturers, Ltd., and The Cement Marketing Company, Ltd., since their formation, has been appointed a Director of the latter Company.

Reinforced Concrete Bridge in Algiers.

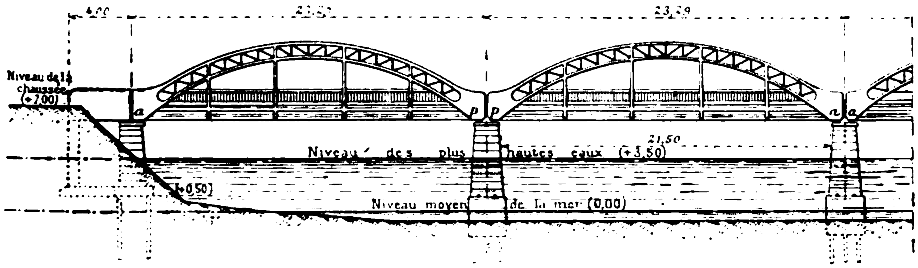
A BRIDGE with some interesting details has recently been constructed to the designs of M. Henry Lossier near Philippeville, Algeria. This bridge, which has a total length of 556 ft., was the subject of a competition in 1923, and the three designs of M. Lossier were approved by the committee which investigated the various plans. These three schemes were for :—

(1) A single span with hollow arch ;
(2) Three bowstring spans ;
(3) Seven equal spans.

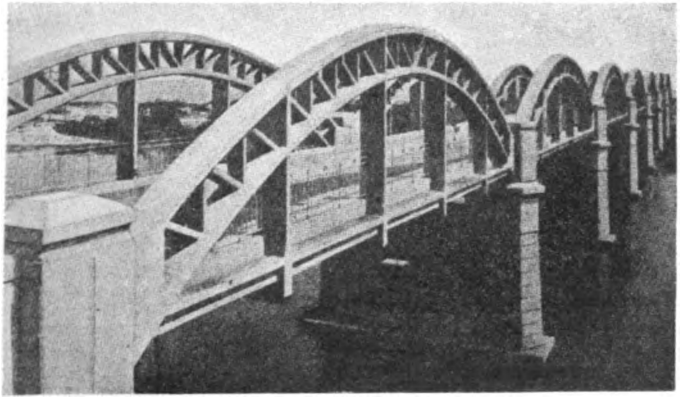
The third design was adopted as being the least costly.

The lay-out consists of seven spans of 76 ft. each, with 21 ft. clear width including 2 footpaths. Each truss is made up of a parabolic arch with two rectangular members joined together by verticals and diagonals, four vertical members and one tension member connected by the four verticals to the arch. Each pair of main vertical members with the corresponding portion of the bridge forms a rigid frame designed to resist wind loads and lateral bending of the arches. At one end the truss rests on a hinge and at the other is supported by an "expansion column" (see illustration).

According to *Le Génie Civil*, from which our description is taken, each of the six piers is composed of two hexagonal towers united by a diaphragm. Each tower is made up from (1) a square reinforced concrete slab resting directly on five piles, which were driven down to the rock ; (2) a hollow hexagonal shaft, constituted of lightly reinforced precast members which were concreted in place with the help of hoops and vertical bars which had been previously left in grooves for this purpose ; (3) an upper hexagonal slab carrying the load from the hinges


4,00
23,29
Niveau de la chaussée (+7,00)
a
p
p
a
a
21,50
Niveau des plus hautes eaux (+3,50)
(+0,50)
Niveau moyen de la mer (0,00)

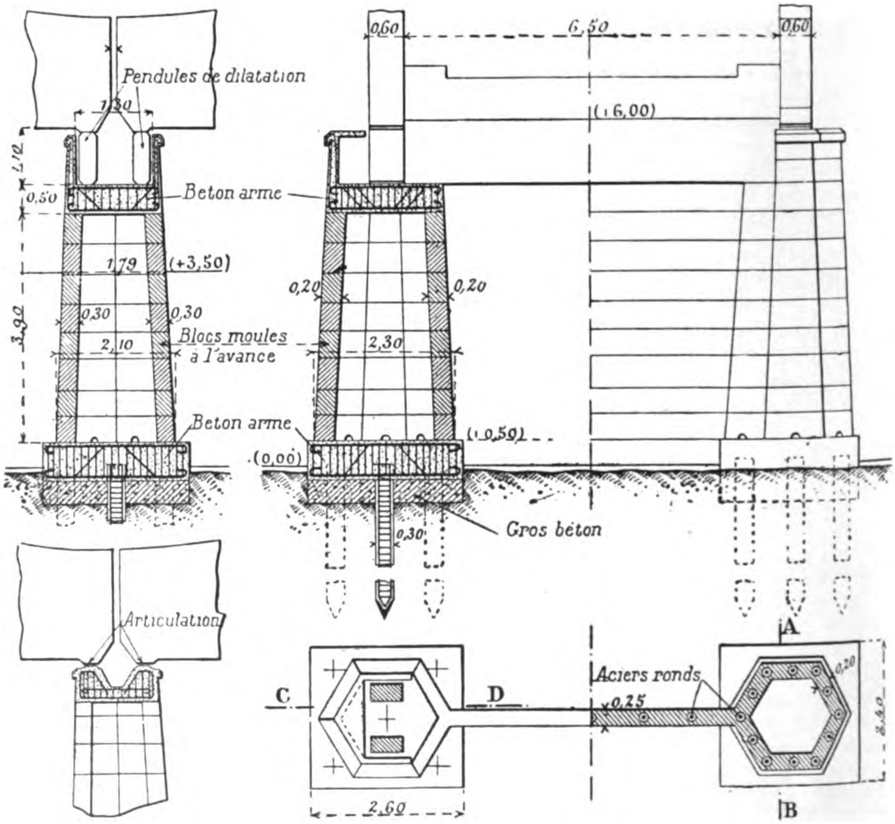
Part Elevation.



Reinforced Concrete Bridge in Algiers.

and "expansion columns" to the tower below.

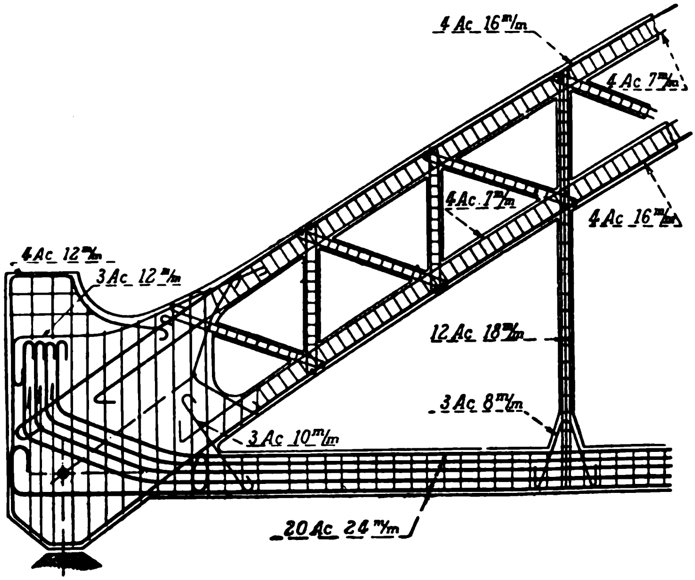
The design was carried out to the French Government rules of 1906 and the specification of 1915 for loads on highway bridges. In addition, allowance was made for the stresses caused by the passage of an 18-ton steam roller over the bridge. As each principal truss is in form a two-hinged arch with a tie-rod the calculation of the stresses was made by the rigorous methods of elastic deformation, taking into account the extension of the tie. The action of moving loads was computed by the use of influence lines and the Principle of Least Work.



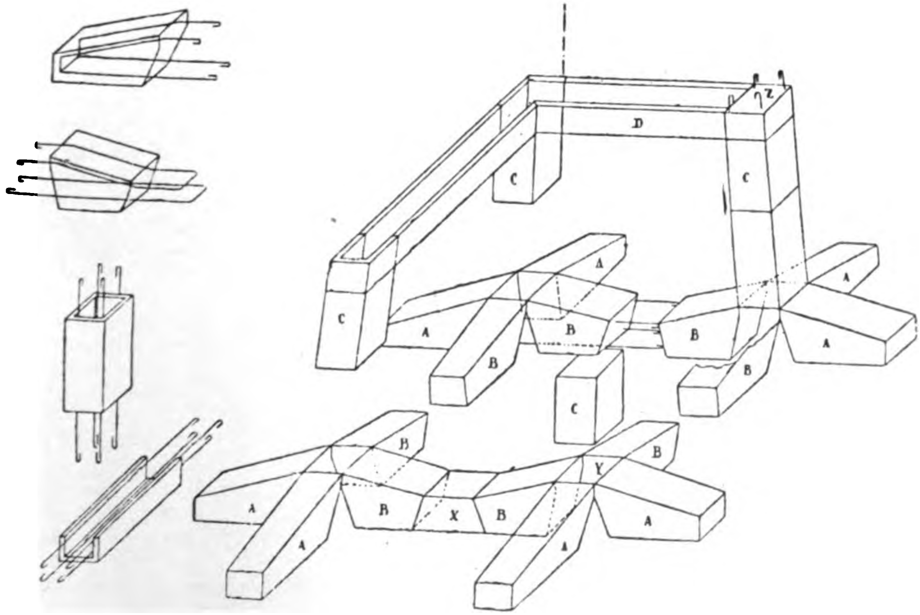
Details of a Pier.

As the seven spans were identical, particular care was taken to make the formwork of such a type that it might be easily taken down and re-erected. It was also carefully wrought in order to avoid rendering of the concrete after dismantling the forms. The centering was supported by sand-boxes and wedges under the principal beams on a timber framework composed of piers, at about 16 ft. centres, braced in all directions.

The concrete used was mixed with 300 kg. of Portland cement to each cubic metre for the main work. For the arch, hinges and "expansion columns" 400 kg. per cb. m. were used.—W. S. G.



Bridge in Algiers: Details of Reinforcement at End of Span. (*See p.* 392).



Foundations for Transmission Line Towers: Fig. 1. (*See p.* 394).

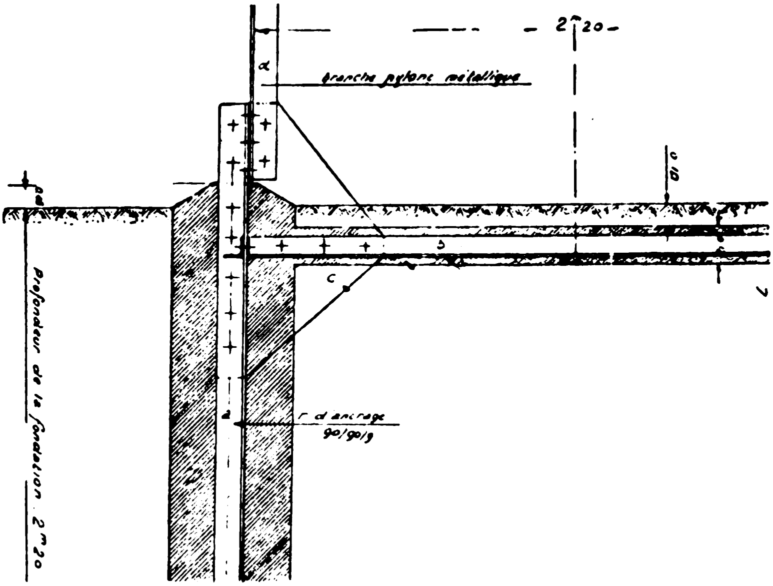


Fig. 2.

Foundations for Transmission Line Towers.

FOUNDATIONS of towers carrying high-tension electric lines are necessarily of large dimensions when constructed of plain concrete, the dimensions depending on the loads and the factor of safety required against overturning.

Transmission lines frequently cross country which is without adequate means of communication by rail or road, involving heavy transport charges for materials and even water.

In Switzerland there are many such lines. For example, the transmission line of the State Railways from Valais to Puidouk, described in a recent issue of "Revue du Beton Armé," has towers 96 ft. high and spans varying from 820 ft. to 1,300 ft. The Swiss regulations require a factor of safety of 1·5 against overturning, which necessitates a foundation of over 700 cb. ft. of mass concrete.

Professor Perrin, of Geneva, has designed an interesting pre-cast foundation for these towers which reduces the cost of transport considerably and has been adopted for a length of nearly 40 miles of this line. Our illustrations show the method of assembling the legs of the tower with the angle-iron projecting from the base and the way in which the pre-cast blocks are erected. Once the excavation has been completed a 4-in. layer of sand is spread over the bottom and the blocks A and B are placed in position, the intervening spaces being concreted with a rich mixture. The hollow members C, which are reinforced and into which the base angles fit, are then assembled in position. The upper ends of the blocks C are united by hollow pre-cast portions D. The latter joints are then concreted and the stub angles project above the back-filling. For the diagram illustrating these blocks see Fig. 1, p. 393.

Before the design was adopted a test was made with very satisfactory results. The difference in cost between a mass concrete footing and the one just described is about 41 per cent. in favour of the new design.—W. S. G.

Recent Reinforced Concrete Work in Germany.

A GREAT deal of interesting reinforced concrete construction has been carried out in Germany during recent years, some of which is illustrated and briefly described in these notes.

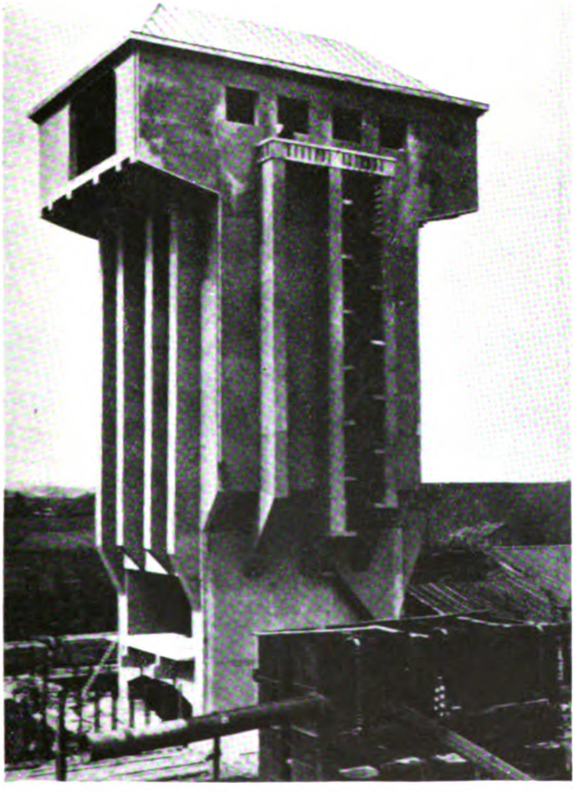
Coal Bunker at Alsdorf.

This bunker has a capacity of 3,000 tons; its height is 168 ft. It is intended for storing fine coal for coking. The charging platforms project on each side in order to provide sufficient room for the cable-way station. The coal bunker forms a cell 78 ft. high. At the bottom of the bunker are 16 delivery openings for supplying coal. In order to protect the tower from damage from subsidence, the foundation slab has a thickness of from 3 ft. 4 in. to 4 ft.

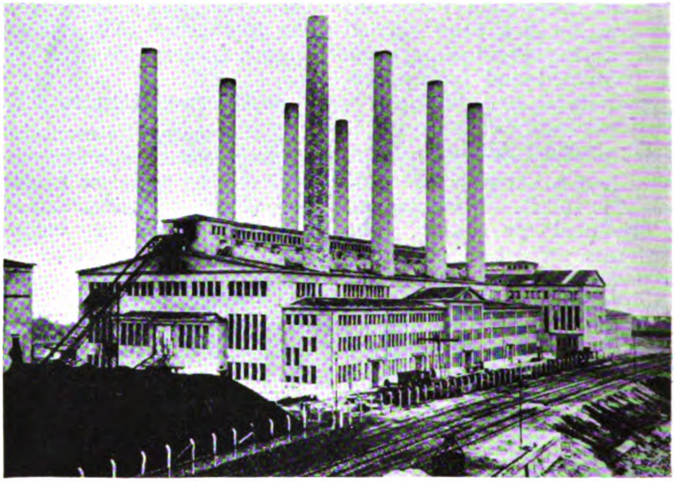
Reinforced Concrete Chimneys.

In Germany the monolithic system of chimney construction seems to have been replaced by pre-cast concrete blocks in conjunction with iron settings, which are now used practically exclusively. It is claimed that the cost of shuttering exceeds the extra expenditure in labour when blocks are used.

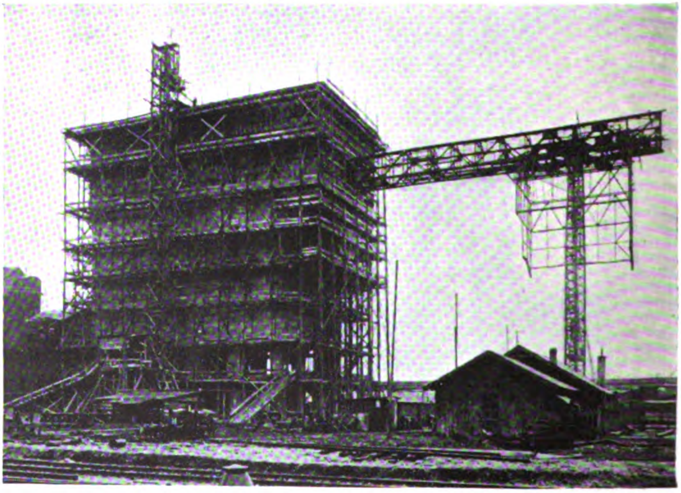
For protecting the concrete against acids and for reducing the heat stresses, the inner covering of the chimneys



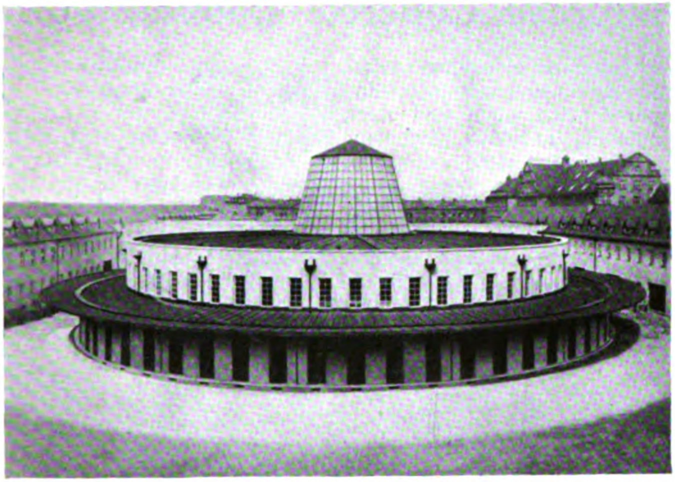
Coal Bunker at Alsdorf.



Reinforced Concrete Chimneys at Mannheim.



Coal Bunkers at Munich.



Parcels Office at Munich.

usually consists of a lining of fireclay blocks, resting on rings of brackets which project on the inside in sections of from 33 to 39 ft. apart. The top end of the lining telescopes into the bottom end of the next section, to ensure uniform movement of the various sections under the action of the heat.

Our illustration shows a group of eight chimneys at the power station at Mannheim. The section here is octagonal. The height of the chimneys is 180 ft.; the inside diameter at the top is 9 ft. An interesting feature is that all the chimneys branch off from the central boiler house.

Coal Bunkers at Munich.

A coal bunker, with coal grinding and mixing plant, has recently been completed entirely in reinforced concrete for the gasworks of the city of Munich. The foundations of the building are 23 ft. deep, and rest on a concrete bed 5 ft. thick. The bunker contains eight hoppers, each one with a capacity of 640 tons of coal. The height of filling is 70 ft.

The most interesting portion of the building is the coal hopper with a capacity of 1,880 tons. This is 66 ft. above ground level, and 16 ft. 6 in. wide, which unloads independently and carries a two-story superstructure. The load of this plant is taken up by a reinforced concrete supporting plate, which in addition supports at its extreme end an iron bridge, together with a delivery hopper installed thereon. The free supporting plate carries a weight of 600 tons.

Although the work was interfered with during more than three weeks by a rush of water, it was found possible to complete the bunker within the short period from June 10 to the end of November.

Parcels Office, Munich.

The new Munich Parcels Office was opened in November last. It is claimed that its arrangement is unique, and as a building it is remarkable in many ways.

The concrete work was commenced in April and the roof was concreted by the end of September. The roof of the building has been concreted in sections with high-grade Portland cement, mixed in the proportion of 1 : 4. This made it possible to use the shuttering twice. The main circular girder is supported by eight columns, and carries the load of the girders which project towards the inside.

The enclosing wall surrounds a rotunda 168 ft. in diameter; the ground floor structure has a diameter of 200 ft.; and the circular roof has an 11-ft. span. A basement 23 ft. deep contains the distribution drums, which send the parcels to the various districts by means of belt transporters.

Reinforced Concrete Cooling Towers.

On p. 349 we refer to the saving in cost of erection of reinforced concrete cooling towers compared with wood and steel, and in the following notes we give some comments on the technical advantages of different types of cooling towers. These notes are from a paper read recently by Mr. T. J. Gueritte, B.Sc., before a recent meeting of the British Section of the Société des Ingénieurs Civils de France.

Dealing with wood towers, he pointed out that timber subjected alternately to damp and dry conditions decays very rapidly. Should a board of the external shell decay and give way the result is an immediate inrush of air, and if this takes place above the distributing troughs, the air flow, not being impeded by the laths and frames which occupy the lower part of the tower, nor by the falling rain, keeps its full strength and considerably disturbs the draught in the lower part, thereby reducing the efficiency of the plant. Consequently one must pay constant attention to the upkeep, and the cost is heavy owing to the difficulties of repair work while the tower is working.

Whatever the care bestowed upon it, a timber cooling tower does not last long. Its life varies according to the country, the quality of the timber, etc., but, analysing figures supplied by engineers in various lands, the average is from 12 to 15 years.

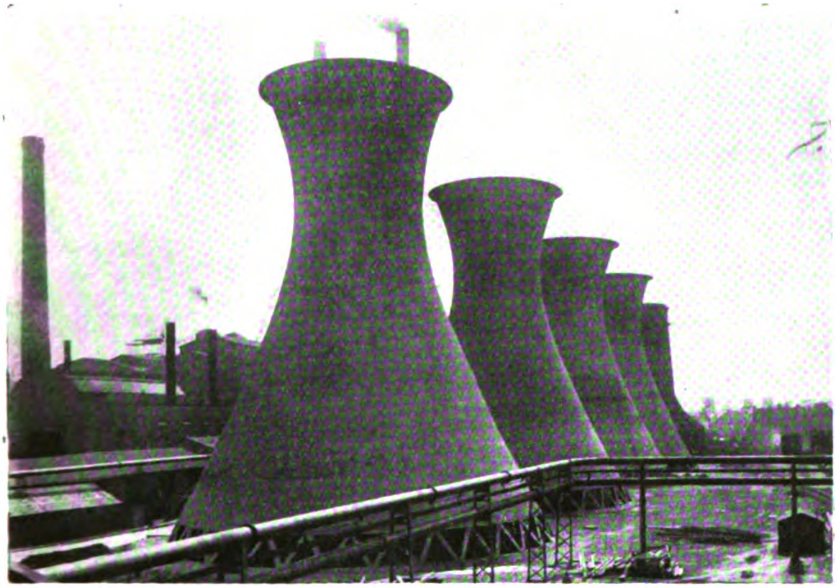
On the other hand, in important plants comprising a great number of towers, several may happen to be out of commission at the same time, either for repair, cleansing, or because during summer months the power station is not working at full capacity. The risk of fire is great, the timber often being impregnated with tar products as a preservative against decay. The destruction by fire of one or more cooling towers is known to have had detrimental effect upon the work of a generating station, and, as a consequence, one of the most important generating stations in Great Britain (Nechells, 225,000 k.w.) has been provided with reinforced concrete fire-screens cantilevered out about 15 ft. to protect the timber towers for a length of about 500 ft. against the sparks from a railway which runs alongside the cooling stacks.

The same object was in view when a recent specification was drafted (Hams Hall, first quarter of a plant for 840,000 k.w.) stipulating that if timber coolers were offered as an alternative to reinforced concrete it would be necessary to provide adequate fire-fighting appliances.

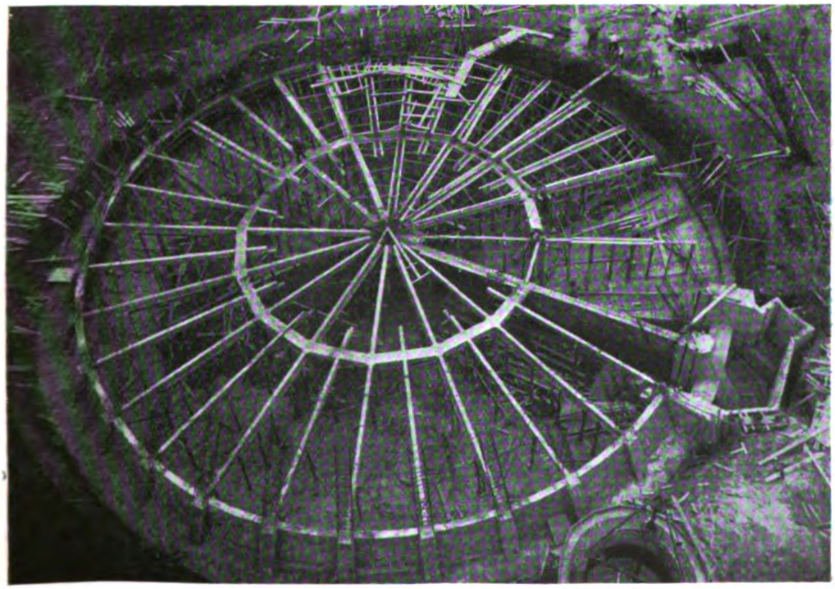
Other considerations, fully as weighty, contribute to the abandonment of timber in the most modern cooling plants. The desirability of circulating a great volume of water necessitates the use either of a great number of small towers or preferably of fewer but much bigger units. In this country the usual type of timber cooler is rectangular, and the width can hardly exceed 36 ft. or 38 ft.; otherwise the air would find difficulties in reaching the central part, the efficiency of which would become nil. Consequently for big plants such towers must be made of great length, which is not without drawbacks as regards the proper distribution of the water. In practice, if the length exceeds 75 or 80 ft. one must provide more than one inlet pipe for feeding the various parts of the long rectangle. A frequent arrangement for big plants consists in providing parallel series of rectangles, 36 to 38 ft. wide by 400 to 450 ft. long at most, spaced at least 15 ft. apart.

But the air circulation is far from satisfactory in such long corridors, and when the wind blows from certain directions it becomes decidedly bad. One finds that with several parallel series of such long rectangular towers the efficiency of the units in the central part is smaller than that of the towers along the borders and smaller again than that of the corner towers, the only ones the efficiency of which approaches that of a similar tower standing by itself.

The enormous flat surfaces of such towers present considerable obstruction to the wind. The width at the base must not be more than 40 ft., and preferably less, so that the stability becomes precarious if one increases the height so as to improve the draught and obviate the loss of efficiency of the central units. In practice, it is difficult to exceed a height of 110 ft. It has been proposed to increase the stability by connecting



Reinforced Concrete Cooling Towers at Heerlen.



Walls of Pond and Supports of Cooling Stack.

Reinforced Concrete Cooling Towers at Liverpool.

the parallel series of towers by means of a network of horizontal metallic ties at their upper part over the passages, but such bracings, notwithstanding the use of the best protective paints, would rust away rapidly in the warm and damp atmosphere which prevails at the top of cooling towers, often contaminated by the presence of smoke from surrounding factories.

In order to overcome such drawbacks metallic towers have been tried and several types are in existence, but notwithstanding the use of the best paints, which render their upkeep very costly, the atmosphere is most detrimental to metallic towers. The circulating water is not always quite pure, and often its chemical impurities increase the rapidity of the corrosion. In various cities in the United Kingdom the life of such towers is estimated not to exceed from six to eight years at most. The prime cost is always high, often from 50 to 80 per cent. or even more, over that of towers designed for the same work, either in timber or in reinforced concrete. Their use seems likely to be restricted to special cases.

Reinforced Concrete Towers.

It was consequently through a natural evolution that reinforced concrete has come to be adopted for cooling towers. When well designed and carried out, a reinforced concrete tower requires no upkeep so far as the shell is concerned, being practically indestructible; it is proof against fire, and may be constructed with perfect safety as high as desired.

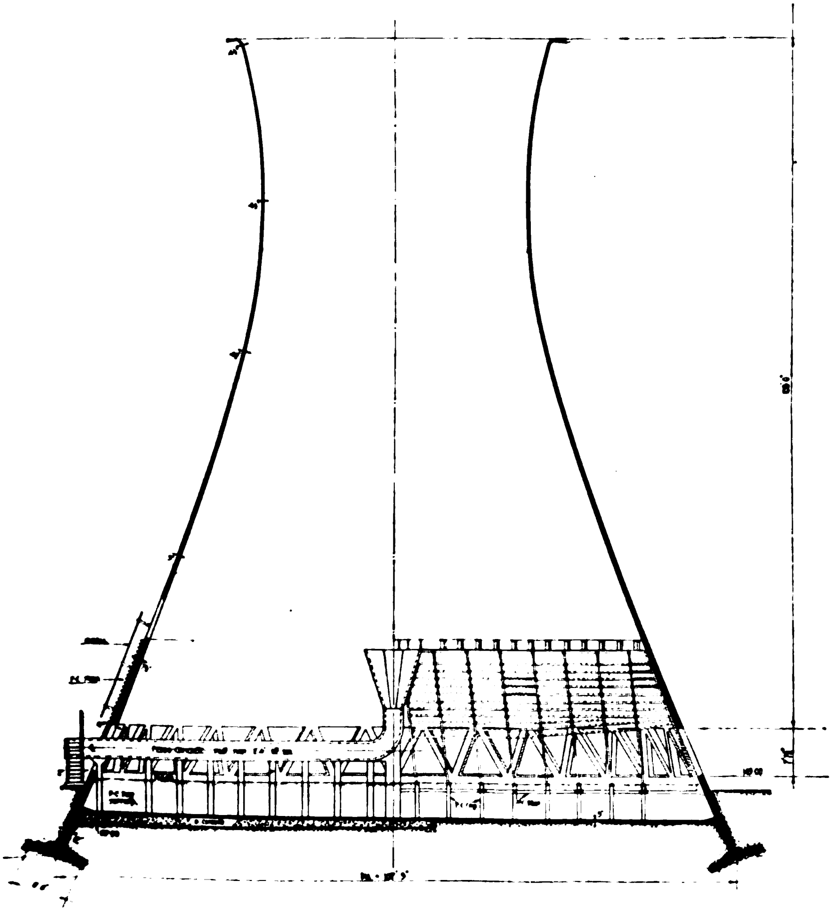
The construction of metallic towers of the circular type had shown the advantage of that shape over that of a rectangle, not only as regards the more even distribution of the water but also as regards the general strength of the structure. As a result, during the last few years many reinforced concrete and also timber towers were built hexagonal, octagonal, etc., in plan. But the difficulties connected with the use of timber for the construction of units of great diameter and height, together with the other drawbacks of timber, do not give such towers a chance to compete successfully with reinforced concrete for big units.

Further, the circular shape is far better than the polygonal from the point of view of the better utilisation of the site. It is well known that when striking the vertical face of a structure rectangular in plan, air streams diverge and create a large "dead space" behind the obstacle. On the contrary, when air strikes a circular cylinder the streams tend to get closer together again behind the cylinder. Consequently the air circulates far more easily throughout a nest of towers when these are circular than when they are rectangular or polygonal, and the drawbacks of the latter are thereby eliminated, there being no further need to maintain large air passage between the various units; narrow spaces are sufficient. The effect is still more marked if, instead of having circular cylinders, one gives to the towers the shape of hyperboloids with vertical axes, the shape which happens to be that which secures the maximum of efficiency for the minimum of cost. In such cases there is no reason why the towers should not be almost in contact at ground-level, leaving between them just a foot or so to allow the passage of the attendants. Many approximately circular towers either cylindrical or conical in elevation have been erected during the last few years in various countries, both in timber and reinforced concrete.

This property of air streams has great importance also as regards the stability of the towers. For moderate speeds and for obstacles of ordinary dimensions the obstruction offered to the stream by a circular cylinder is only 56 per cent. of that offered by a prismatic body of same projection. Recent experiments at the aerodynamical laboratory in Göttingen show that for very great speeds and very large obstacles the wind pressure against a smooth cylinder is less than 25 per cent. of that against a flat surface when the wind blows at an angle of about 35 deg. It is well known that very few timber cooling towers remain standing when they find themselves on the path of a cyclone. It should be noted, however, that the advantage attaching to a smooth cylinder is considerably reduced if the cylinder, instead of being smooth, is provided with projecting ribs or pilasters. The whole question of the flow of fluids has great importance in cooling tower designing, not only as regards the external shape, but also concerning the details of construction and in particular the internal arrangements.

The general trend is in favour of large units. All other conditions being equal, and assuming that one can ensure an adequate and uniform distribution of the air stream throughout the whole area of a tower, its efficiency is proportional to the rain area. A tower 100 ft. diameter does the same work as four towers of 50 ft. diameter. As the area of its walls is only one-half of the total wall area of the four smaller units, as the inlet piping is less costly for the one big unit than for the four small ones, and as the same applies to the ponds, the bigger unit is more economical.

Cylindrical towers, however, present a difficulty, for as soon as the diameter reaches a certain figure the air which enters through the openings provided for that purpose along the periphery of the cylinder, near the ground, is distributed very unequally throughout the area of the cylinder. The fresh air is warmed up immediately it enters, and has a tendency to rise vertically instead of going toward the central part; the small quantity of air which may reach the centre is too warm to be really efficient. Consequently there is bad utilisation of the central space, and the advantage in favour of big units of this shape is considerably discounted if not wiped out. To remedy this drawback cylindrical towers have been provided with special air ducts taking the fresh



Reinforced Concrete Cooling Towers: Typical Section.

air from a number of points on the periphery and bringing it to the central part, but this is a clumsy solution of the difficulty. The ducts, to be efficient, must be of large dimensions; they interfere with the general circulation of the air, set up eddies, and produce inequalities in the cooling power of the various parts of the area, together with a lowering of the efficiency of the peripheric parts.

In connection with the cooling equipment of the power stations in the various Dutch State Mines of which he is Director, Professor van Iterson had occasion to study many types used in various countries. Their drawbacks had struck him and he had come also to the conclusion that the "guarantees" of cooling efficiency were often quite illusory. He was thus led to design, in collaboration with Mr. G. Kuypers, Chief Engineer for the control of new structures of the City of Amsterdam, a cooling tower based on entirely different principles.

Advantages of the Hyperbolic Shape.

Its shape is hyperbolic. The reinforced concrete shell is quite smooth without any projecting pilasters, beams, or counterforts, either inside or outside, thereby securing an air circulation as regular as possible. The hyperbolic shape, adopted after Eiffel, eliminates the shearing stresses, the construction of the shell becoming most economical. The great strength of a double curvature shell of this kind makes it suitable for resisting the most severe storms without having to provide internal bracings, thus avoiding the formation of eddies which would interfere with the regularity of the air flow. The hyperbolic shape automatically directs the air streams entering the tower toward the centre part, and induces an excellent draught. The widening out of the top part reduces the speed of the column of air saturated with steam, avoiding eddies around the cornice, and permits the recuperation of a certain quantity of the water lost through evaporation, and which begins to condense after leaving the zone of over-saturation existing in the lower part of a cooler of maximum efficiency. On the other hand, the spreading out of the lower part of the shell causes the water drops to fall always in the pond without necessitating the provision of louvres, such as are necessary in other types of towers, and which considerably obstruct the air ingress.

The monolithic nature and lightness of such a shell procure a great saving in the cost of foundations as there are no point loads, the loading being very uniformly distributed. For instance, a tower approximately 100 ft. diameter and 125 ft. high brings less than 2 tons per foot run at the base, including wind pressure. The enormous strength of such structures cannot be illustrated better than by the following instance: The cooling towers at Pit Emma (Holland) are just over the colliery workings. Unequal roof subsidences took place a few years ago, and one of the towers and its pond had to follow the movement of the ground. One end of a diameter went down just over 3 ft. more than the other end, and the tower itself tilted proportionately. It became necessary to carry out some repairs for re-establishing the horizontality both of the edge of the pond wall and of the water distributing troughs, etc., but the structure exhibited no trace of fatigue either during the repairs or since.

The water is distributed over the hurdles by means of radial troughs which feed subsidiary troughs arranged in parallel concentric lines, thereby ensuring a uniform distribution in each triangular sector. Water jets issue through conical nozzles and strike spray cups of special shape, a fine spray resulting and falling upon the hurdles or laths. These are sloping towards the outside; from an inclination of 45 deg. at the top, they become almost horizontal at the lower part of the stack. The water falling from the bottom of a lath to the top of the following one thereby progresses toward the periphery, and the speed of its fall is gradually reduced. Consequently it has longer contact with a cooler air in proportion as it becomes itself cooler. The varying slope of the laths has also for object the guidance of the air streams toward the central part of the tower along the regular curves without abrupt changes of direction, and with the least possible obstruction. The position of the nozzles is carefully arranged so that the density of the rainfall in any point be in suitable proportion to the quantity of air and the exchanges of heat expected at that point.

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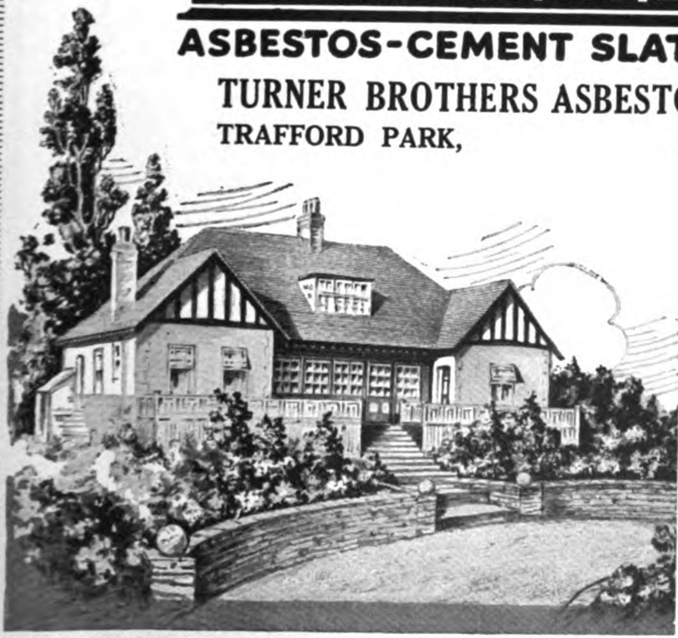

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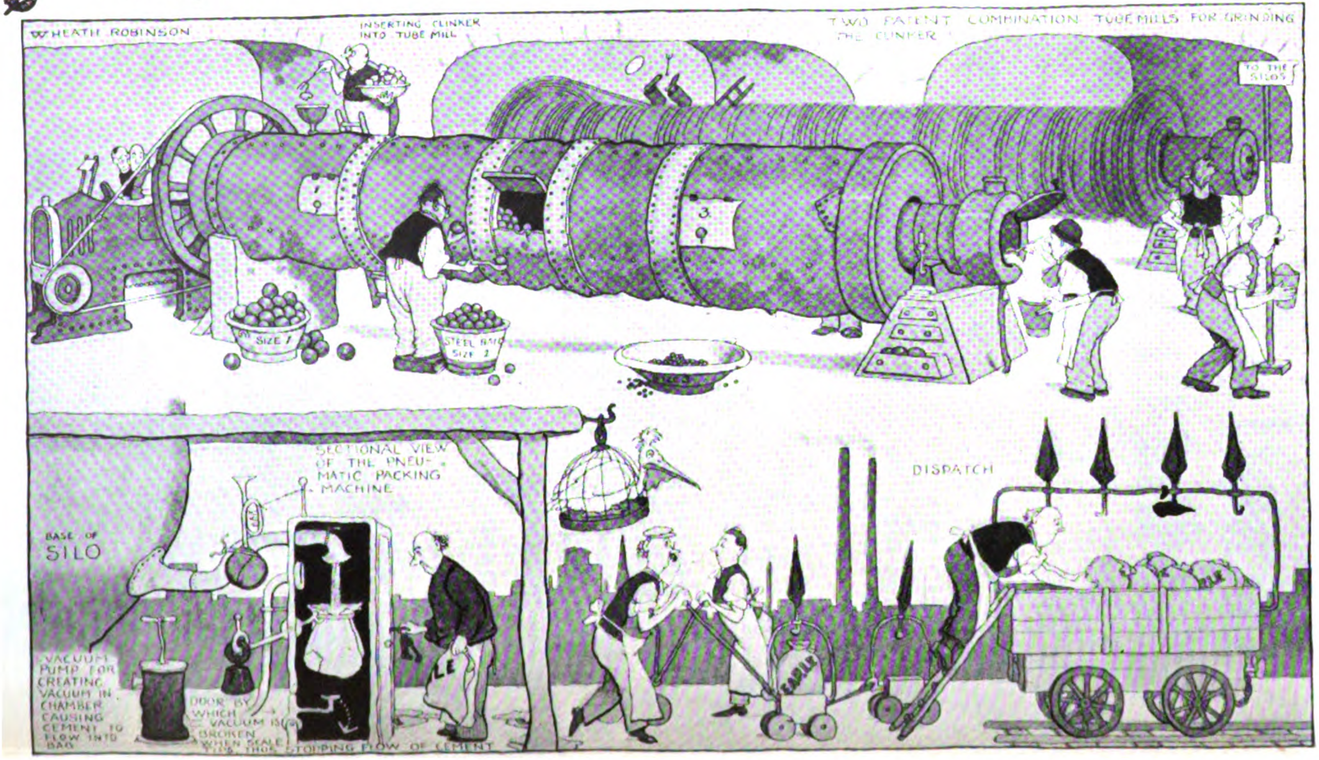
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INSERTING CLINKER INTO TUBE MILL
TWO PATENT COMBINATION TUBE MILLS FOR GRINDING THE CLINKER
TO THE SILOS
SIZE 1
STEEL BALLS SIZE 2
3
SECTIONAL VIEW OF THE PNEUMATIC PACKING MACHINE
BASE OF SILO
VACUUM PUMP FOR CREATING VACUUM IN CHAMBER CAUSING CEMENT TO FLOW INTO BAG
DOOR BY WHICH VACUUM IS BROKEN WHEN SCALE TIPS THUS STOPPING FLOW OF CEMENT
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CEMENT MANUFACTURE — 4. The cement clinker is conveyed from the stores to grinding mills where it is reduced to a powder of such fineness that nearly all of it will pass through a sieve which has 32,400 holes to the square inch. The mills are long cylinders in which are contained steel balls. As the mills rotate these balls are propelled round, and crush and rub the clinker to a fine powder. The cement thus ground is conveyed to silos, and is later packed by a pneumatic packer similar to Mr. Heath Robinson's design.

Reinforced concrete hyperbolic towers can be made for all capacities. In practice, however, they are seldom built for less than 50,000 g.p.h. The smallest now at work (pit Hendrik, Holland) may work with a load from 44,000 to 100,000 g.p.h. For many years the most powerful type remained that used at the pits Emma and Wilhelmina (Holland), at Liverpool, at Cairo (225,000 to 950,000 g.p.h). Bigger units were erected at Leicester, Coventry, Pit Maurits (300,000-1,200,000 g.p.h.). The biggest so far designed, for the Birmingham Electricity Works, can cool from 1,200 to 4,800,000 g.p.h. It is recommended to work normally with 3,200,000 g.p.h., being coupled to a 40,000 k.w. turbo set. Credit for the introduction of hyperbolic towers in this country is due to Mr. H. Dickinson, M.I.C.E., M.I.E.E., City Electrical Engineer, Liverpool, who, following tests carried out in Holland by his Deputy, Mr. P. J. Robinson, M.I.E.E., caused three such towers to be erected in Liverpool in 1925. In view of the very satisfactory results obtained, two more units are now being erected. The whole battery will consist of 13 towers.

Generally speaking the capacity of timber cooling towers does not reach 100 gallons per sq. ft. covered. Hyperbolic cooling towers have brought about a marked advance in that respect. The Coventry type cools efficiently over 150 gallons and the Birmingham type 220 gallons per sq. ft. covered. For the small Hendrik type the maximum is about 120 gallons per sq. ft. covered. This is due largely to the great height given to the big units ,which induces a powerful draught. While the height of Hendrik type is only 65 ft., Coventry approaches 130 ft., and Birmingham exceeds 200 ft.

Reinforced Concrete Towers at Liverpool.

The reinforced concrete towers illustrated are the first built for the Liverpool Corporation on the Mouchel-Hennebique system as the first part of a scheme including the construction of twelve cooling towers. Each tower is 122 ft. 6 in. high measured from the bottom of the cooling pond beneath it, and 130 ft. high from foundation level, the diameter being 100 ft. at ground level and 107 ft. 5 in. at foundation level. The lightness of the shell is evident from the section, the wall being 12 in. thick at the base, progressively reduced to 7½ in. and 5 in. in the lower half, the upper half being only 4½ in. thick. The lower part of the tower encloses a cooling pond with a water depth of 5 ft. 6 in., and connected with this are discharge ducts with sumps and manholes, the ducts leading to a general suction culvert. Reinforced concrete supports are provided for the inlet main, of 28 in. internal diameter, and for the timber cooling stacks,

The inlet pipe is brought to the centre of the tower, where it bends up and discharges through a funnel inverted conical shape (thus reducing the speed of the water at the point of discharge). At the top of the cooling stack eight radiating troughs carry the water towards the shell, and in their turn feed eleven subsidiary gutters. Along the length of the latter are distributed spray nozzles which discharge the water on earthenware saucers fixed some 18 in. lower down. The shape of these is such that the splashing water is transformed into a fine spray ; the drops of water fall from lath to lath down into the pond.

The design for the towers of Leicester Power Station shows an advance in cooling efficiency upon that of the above described Liverpool towers. With approximately the same diameter at ground level, but with a slightly greater height, each of the towers is designed to cool continuously 700,000 g.p.h. from 88 deg. to 75 deg. when the wet bulb temperature of the air is 55 deg. There will be ultimately eight towers to deal with over 5,500,000 g.p.h.

DATA FOR PRICING REINFORCED CONCRETE.*

MATERIALS DELIVERED 4 MILES FROM CHARING CROSS.

		s.	d.
Best Washed Sand	per yard	16	0
Clean Shingle, ¾ in. mesh	„	14	0
„ „ ⅜ in. mesh	„	15	6
Thames ballast	„	10	6
Broken brick (¾ in.)	„	11	6
Best British Portland Cement (delivered London area)	per ton 58s. to	63	6
Rapid-Hardening Portland Cement	delivered London 10s. per ton extra		
"Super-Cement"	per ton 88s. to	93	0
"Lightning" Brand Aluminous Cement	„ 100s. to	105	6
Ciment Fondu	works f.o.r.	95	0

Boarding for Shuttering—

		Sawn. s.	Sawn. d.	Wrot. s.	Wrot. d.
1 in.	per square	23	6	27	6
1¼ in.	„	29	6	33	6
1½ in.	„	35	6	41	0

Sawn Timber for Struts and Supports—

3 in. by 4 in.	from £22 per standard
3 in. by 6 in. and 3 in. by 7 in.	„ £20 „ „

Mild Steel Rods for Reinforcement—

		s.	d.
⅝ in. to 2⅞ in. Rounds	per cwt.	10	6
7/16 in. to ½ in. Rounds	„	10	9
⅜ in. Rounds	„	11	0
¼ in. Rounds	„	12	0

Breeze Slabs per yd. super: 2 in., 1/11; 2½ in., 2/4; 3 in., 2/9; 4 in., 3/6.

MATERIAL AND LABOUR, INCLUDING 10 PER CENT. PROFIT.

(Based on Contracts up to £2,000.)

Portland Cement Concrete well mixed in proportion 1 : 2 : 4—

				s.	d.
Do.	do.	in foundation	per foot cube	1	11
Do.	do.	in columns	„ „	2	1
Do.	do.	in beams	„ „	2	3
Do.	do.	in floor slabs 4 in. thick	per yard super	6	0
Do.	do.	in floor slabs 5 in. thick	„ „	7	6
Do.	do.	in floor slabs 6 in. thick	„ „	9	0
Do.	do.	in floor slabs 7 in. thick	„ „	10	6
Do.	do.	in walls 6 in. thick	„ „	8	8

(Add for hoisting 3s. 6d. per yard cube above ground-floor level. Add for "Ferrocrete" 1s. 10d. per yard cube.)

Steel Reinforcement, including Cutting, Bending and putting into Position and securing with Stout Binding Wire—

		s.	d.
From ¼ in. to ⅜ in.	per cwt.	22	6
„ 7/16 in. to ½ in.	„	21	6
„ ⅝ in. to 2⅞ in.	„	20	6

EXTRA LABOUR TO BENDS in ¼-in. rods, ½d.; ⅜-in. rods, 1d.; ½-in. rods, 1¼d.; ⅝-in. rods, 1½d.; ¾-in. rods, 1¾d.; ⅞-in. rods, 2d.; 1-in. rods, 2¼d.; 1⅛-in. rods, 3d.; 1¼-in. rods, 3½d.; 1⅜-in. rods, 4½d.; 1½-in. rods, 6d. (per bend per cwt.).

EXTRA LABOUR TO HOOK BENDS: ¼ in., 1d.; ⅜ in., 2d.; ½ in., 2½d.; ⅝ in., 3d.; ¾ in., 3½d.; ⅞ in., 4d.; 1 in., 4½d.; 1⅛ in., 6d.; 1¼ in., 7d. (per bend per cwt.).

Shuttering—

		s.	d.
Shuttering and Supports for Concrete Walls (both sides measured)	per square	59	0
Centering to Soffits of Reinforced Concrete Floors and Strutting, average 10 ft. high	per square	55	0
Do. do. in small quantities	per ft. super	0	10
Shuttering and Supports to Stanchions for easy removal, average 18 in. by 18 in.	per ft. super	0	11½
Do. do. as last, in narrow widths	„ „	1	1½
Do. do. to sides and soffits of beams, average 9 in. by 12 in.	„ „	1	1½
Do. do. as last, in narrow widths	„ „	1	3½
Raking, cutting, and waste to shuttering	per ft. run	0	3
Labour, splay on ditto	„ „	0	2
Small angle fillets fixed to internal angles of shuttering to form chamfer	„ „	0	3

WAGES.—The rates of wages on which the above prices are based are:—Carpenters and joiners, 1/9½ per hour; Carpenters working on old shuttering, 1/10½; Labourers on building works, 1/4½; Men on mixers and hoists, 1/5½; Bar-benders, 1/5½.

[* This Data is specially compiled for *Concrete and Constructional Engineering*, and is strictly copyright.]

Prospective New Concrete Work.

Abram.—*Houses.*—A site has been purchased on which to erect 50 houses.

Alrewas.—*Bridge.*—The Staffs. C.C. proposes to erect a bridge over the Trent and Mersey Canal at Alrewas. The cost is estimated at £4,500.

Becontree. — *Houses.* — The L.C.C. proposes to erect 2,221 houses on the Becontree estate, at an estimated cost of £1,270,000.

Bedlington. — *Concrete Bridge.* — A reinforced concrete bridge is to be constructed over the river, at an estimated cost of £2,000.

Beeston.—*Houses.*—The U.D.C. has applied for sanction to borrow £18,000 for the erection of 42 houses.

Bethesda. — *Concrete Houses.* — The U.D.C. is considering a scheme for the erection of concrete houses to cost £380 each.

Bourne.—*Road.*—The U.D.C. has authorised the Surveyor to prepare plans for the construction of a road from Twenty Station to Tongue End.

Brenchley.—*Reservoir.*—A reservoir of a 500,000-gallon capacity is to be constructed at Brenchley for the South Kent Water Co.

Bridgnorth.—*Road.*—The Salop C.C. and the Cleobury Mortimer R.D.C. are considering a scheme for the construction of a road from Bridgnorth to Highley Police Station. The cost is estimated at £27,500.

Bridgwater.—*Groynes.*—The Somerset Drainage Commissioners propose to spend £500 on the construction of groynes at Bridgwater.

Brighton.—*Houses.*—The T.C. is considering the erection of 184 houses on the North Moulescombe estate, at an estimated cost of £101,200.

Bristol.—*Concrete Culvert.*—The Corporation has applied for sanction to borrow £8,300 for the construction of a reinforced concrete culvert from Zetland Road to Cheltenham Lane.

Caherciveen.—*Bridge.*—The Kerry C.C. has applied for sanction to borrow £6,375 for the construction of Caherciveen Bridge.

Caldervale.—*Bridge.*—The Lanarkshire Western District Committee recommends the construction of a footbridge over the River Calder at Caldervale. The cost is estimated at £200.

Cardiff.—*Roads.*—A conference is to be held to consider a proposal to construct seven roads at an estimated cost of £766,191.

Carmarthen.—*Bridge.*—A scheme is being considered for the provision of a high-level bridge over the Towy.

Chester.—*Bridge.*—The Corporation Improvement Committee's town-planning scheme includes a proposal to construct a bridge in the Saughall Road district.

Chiswick (London).—*Concrete Paving.*—The Brentford and Chiswick U.D.C. proposes to spend £366 on concrete paving in the High Road.

Church Bay.—*Pier Works.*—The Antrim C.C. proposes to reconstruct the Pier at Church Bay, Rathlin Island, at an estimated cost of £3,000.

Colchester.—*Road.*—Plans for the provision of a road from Cambridge Road to Maldon Road are being considered by the T.C.

Cushendun.—*Road.*—The Antrim C.C. is considering a scheme to construct a road seven miles in length from Cushendun to Ballycastle. The cost is estimated at £35,200.

Dunblane.—*Bridge.*—The Perthshire C.C. proposes to spend £1,500 on the construction of a bridge over the River Allan at Dunblane.

Dundee.—*Road.*—A road is to be constructed from Dudhope Terrace to Lochee Road at an estimated cost of £10,000.

Drewsteignton.—*Road.*—The Okehampton (Devon) R.D.C. is considering a proposal to construct a road from Drewsteignton to Fingle Bridge.

Easington.—*Houses.*—The R.D.C. has applied for sanction to build 50 houses.

Eastbourne.—*Houses.*—The Housing Committee is considering a proposal to erect 500 houses.

Edinburgh.—*Pier, etc.*—Application has been made for permission to borrow £136,000 for the construction of an aqueduct in connection with the Portobello Electricity Station; a reinforced concrete pier at Portobello; and a mass concrete wall for enclosing part of the foreshore for use as open-air baths, etc.

Finnieston.—*Bridge.*—The Glasgow T.C.'s scheme for the construction of a bridge over the Clyde at Finnieston has been approved by the Commissioners. The cost is estimated at £1,000,000.

FLEETWOOD. — *Sea Wall, etc.* — The U.D.C. is promoting a Bill in Parliament providing for the construction of a sea wall, groynes, and a marine lake on the foreshore. The scheme is estimated to cost £55,000.

GLANAMMAN. — *Bridge.* — The Gellyceidrim Colliery Co. propose to erect a bridge over the main road at Glanamman.

GRANGEMOUTH.—*Houses.*—The T.C. proposes to build 60 houses.

HEMPNALL. — *Concrete Bridge.* — The C.C. has notified the Depwade R.D.C. that it has agreed to construct a reinforced concrete bridge over the ford at Hempnall. The cost is estimated at £790.

HILL HEAD.—*Sea Defence Work.*—The Fareham R.D.C. is seeking permission to borrow £2,708 for sea defence work at Hill Head.

HUDDERSFIELD.—*Road.*—The Highways Committee has approved a proposal to construct an arterial road from Northayte into Wakefield Road.

INVERLOCHY.—*Concrete Bridge.*—The Inverness-shire C.C. is considering a proposal to spend £30,000 on the construction of a reinforced concrete bridge over the river Lochy near Inverlochy.

INVERNESS.—*Houses.*—The T.C. proposes to build 100 houses.

JOHNSTONE.—*Houses.*—The T.C. is considering a scheme for the erection of 44 houses.

LOWESTOFT.—*Sea Defence Work.*—The T.C. has applied for sanction to borrow £2,242 for the construction of a sheet-piled concrete wall near the Victoria bathing chalets.

MAEISSA.—*Bridges.*—The Llandovery R.D.C. has instructed the Engineer to prepare plans for the construction of bridges at Maeissa and Aberbranddu.

MAENCLOCHOG.—*Bridges.*—The Pembrokeshire C.C. has approached the Narberth R.D.C. with a view to providing bridges over the streams in the parish of Maenclochog.

MAGHERY, CO. ARMAGH.—*Bridge.*—A proposal is being considered for the erection of a bridge over the river Blackwater at Maghery Ferry.

MELTON.—*Retaining Wall.*—The Highways Committee of the Leicestershire C.C. recommends the construction of a retaining wall at Nottingham Road, Melton. The cost is estimated at £815.

MEPAL.—*Bridge.*—The Ouse Drainage Board has notified the Isle of Ely C.C. that it is prepared to contribute £1,000 towards the cost of constructing a bridge at Mepal.

MILNROW.—*Houses.*—The U.D.C. has decided to erect 30 houses at Two Bridges, Newhey.

MONTROSE.—*Concrete Bridge.*—The Montrose T.C. and the Forfar County Road Board recommend the construction of a reinforced concrete bridge over the river Esk. The cost is estimated at £73,350.

MUSSELBURGH. — *Houses.* — The T.C. proposes to build 52 houses on the Monktonhall housing site.

NEWRY.—*Bridge.*—The U.D.C. is negotiating with the Port and Harbour Trust with a view to replacing Godfrey Bridge.

NEYLAND.—*Jetty.*—The Pembrokeshire Main Roads Committee has appointed a sub-committee to inquire into a proposal to construct a jetty at Neyland.

NUNEATON.—*Houses.*—The Architect has received instructions to prepare plans for the erection of 80 houses.

PENMAENMAWR.—*Concrete Houses.*—The U.D.C. has decided to build 36 concrete houses.

PONTEFRACT.—*Concrete Water Tower.*—The Corporation proposes to spend £3,300 on the construction of a reinforced concrete water tower.

POOLE.—*Concrete Road.*—The T.C. proposes to spend £5,000 on reconstructing Banks Road in reinforced concrete.

RACKMILL.—*Concrete Bridge.*—The M.T. has recommended the Clackmannan C.C. to construct a reinforced concrete bridge at Rackmill.

RAMSGATE.—*Bridge.*—A bridge is to be constructed at the Lord of the Manor crossing. The cost is estimated at £16,000.

ROCHESTER. — *Houses.* — Application has been made for sanction to borrow £36,474 for the erection of houses on the Maidstone Road site.

ROSS.—*Houses.*—The U.D.C. is considering a scheme for the erection of 100 houses.

SEDGEFIELD.—*Water Storage Tank.*—The R.D.C. has been recommended to construct a water storage tank, estimated to cost £1,200.

SHIREHAMPTON.—*Houses.*—The Bristol City Council proposes to erect 200 houses by direct labour. The cost is estimated at £86,000.

SIDMOUTH.—*Groynes.*—A scheme for the construction of groynes for the protection of the sea front is being considered by the Sidmouth U.D.C.

SMETHWICK.—*Houses.*—The Corporation is seeking permission to borrow £26,634 for the construction of 64 houses in Alexandra Road.

SOUTHWOLD.—*Groynes.*—The T.C. is seeking permission to borrow £4,000 for the construction of groynes.

STIRLINGSHIRE.—*Houses.*—The Eastern District Committee of the C.C. has approved a scheme for the construction of 212 houses. The cost is estimated at £95,400.

STONELEIGH.—*Bridge.*—The Warwickshire C.C. has applied to the M.T. for a grant towards the construction of a bridge on the Stoneleigh to Leamington Road. The cost is estimated at £14,500.

THORNTON.—*Groynes.*—The U.D.C. is seeking permission to borrow £1,000 for the construction of groynes on the foreshore.

WALLSEND.—*Houses.*—Application has been made for sanction to borrow £50,280 for the construction of houses and street works.

WINDSOR.—*Houses.*—Application has been made for sanction to borrow £19,084 for the erection of 52 houses in Dedworth Road.

WREXHAM. — *Houses.* — The R.D.C. proposes to erect 328 houses in the rural area.

UTTOXETER.—*Concrete Swimming Bath.*—The U.D.C. has decided to construct a reinforced concrete open-air swimming bath to hold 225,000 gallons.

SITUATIONS VACANT.

REINFORCED Concrete Designers (two) required, with specialist training. Applications stating age, experience and salary required, to Box 1270 CONCRETE AND CONSTRUCTIONAL ENGINEERING, 20 Dartmouth Street, Westminster, S.W.1.

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Tenders Accepted.

Acton (London).—*Concrete Footpaths.* —The T.C. has accepted the tender of Mr. H. Morecroft, Acton, at £387, for paving Winchester Street with cast stone. Other tenders submitted: F. Jackson, £382; A. C. Valley, £404; G. Wimpey & Co., Ltd., £406; J. Mowlem & Co., Ltd., £417; Mears Bros., £453; E. J. Harris & Co., Ltd., £473.

Antrim.—*Concrete Roads.*—The County Council has accepted the tender of Mr. J. Graham, at £42,112, for constructing in reinforced concrete the following roads:—Lisburn to Lurgan; Belfast to Antrim; Antrim to Ballymena; Ballymoney to Coleraine.

Brimscombe.—*Bridge.*—The Stroud R.D.C. has accepted the tender of Messrs. Orchard & Peer, at £517 10s., for the construction of a steel and concrete bridge.

Dolgelly.—*Concrete Road.*—The Merioneth C.C. has accepted the tender of Messrs. Davies Bros., Barmouth, at £11,068, for improving, strengthening and resurfacing with concrete about 1¼ miles of Talyllyn Road between Dolgelly and Machynlleth. Other tenders submitted: W. P. Taylor & Co., Ltd., £11,252; James Byrom, Ltd., £11,355; H. Coxhead & Co., Ltd., £11,373; C. L. Warren, £11,484; Whitley Bros., £11,543; Fothergill Bros., £11,820; A. Blair, Lyell & Co., Ltd., £12,089; M. Harrison & Co., Ltd., £12,324; S. & J. Smethurst, Ltd., £12,895; W. Turner (Ardwick), Ltd., £13,199; Walker-Weston Co., Ltd., £13,400; Sir W. Prescott & Sons, Ltd., £14,066; J. Morgan, £14,134; A. E. Farr, £14,804; Hobrough & Co., Ltd., £19,087.

Dundee.—*Concrete Piling.*—The T.C. has accepted the tender of the Yorkshire Hennebique Contracting Co., Ltd., at £822, for concrete piling work at Carolina Port.

Gravesend.—*Concrete Houses.*—The T.C. has accepted the tender of Mr. Jesse Clements, at £48,470, for the construction of 114 concrete houses.

Hemsworth.—*Concrete Fencing.*—The R.D.C. has accepted the tender of the Housing Corporation of Great Britain, Ltd., at £3,040, for the construction of reinforced concrete fence posts for the Council's housing schemes.

Metham (Yorks).—*Outfall.*—The East Riding C.C. has accepted the tender of Messrs. H. Connell & Son, Selby, at £965, for the construction of a concrete tube outfall on a piled foundation.

Paisley.—*Concrete Bridge.*—The T.C. has recommended for acceptance the tender of Messrs. Gray's Ferro-Concrete Co., Ltd., at £11,000, for the construction of a reinforced concrete bridge over the river Cart.

Rotherham.—*Bridge.*—The T.C. has accepted the tender of the Yorkshire Hennebique Contracting Co., Ltd., at £58,600, for the reconstruction of Chantry Bridge.

Southsea Common.—*Concrete Bandstand.*—The Portsmouth T.C. has accepted the tender of Messrs. Sadler & Co., Dollis Hill, at £939, for the construction of a reinforced concrete bandstand. Other tenders submitted: Tanner Bros., Southsea, £1,518; Frank Bevis, Ltd., £1,250; E. & A. Spriggins, Portsmouth, £1,138.

Suspended Ceilings.—The simplification of their construction by modern invention has brought the suspended ceiling into increasing popularity amongst architects. The method in general use is to suspend the ceiling from the floor or roof above by means of steel hangers, which are embedded in the floor and may be of any length. These hangers may also vary in length when a vaulted ceiling is required. For those interested in this type of construction the Self-Sentering Expanded Metal Co., Ltd., of 112, Cannon Street, London, E.C.4, have issued a booklet fully describing and illustrating the system adopted on a number of important new buildings, including churches, cinemas, dance halls, stores and railway stations. In this system the steel hangers are connected by a framework of steel rods, to which the firm's well-known expanded mesh steel reinforcement is attached to give the desired shape to the ceiling; this mesh is supplied in various gauges according to the spacing of the runners. The ceiling is finished by plastering with Portland cement plaster. The booklet referred to gives working drawings showing the method of construction as used on actual buildings, and fully describes the method of construction and the best method of plastering; copies will be sent post free to readers mentioning this journal.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XXII. No. 7. LONDON, JULY, 1927.

EDITORIAL NOTES.

Concrete Architecture.

FOR the past thirty years architects and engineers have been confronted with the problem of evolving a definite style of architecture for concrete. The problem, it is true, is one of their own making, but to be able to design a building in concrete that will be unmistakably concrete, that the passer-by will recognise as concrete because of its form, is a legitimate aspiration. Steel has passed, and is still passing, through the same stage of evolution in design. The architect feels that when he uses a steel frame as the structural basis of his building that fact should be expressed in his elevations, and be obvious to the man in the street. To a certain extent he has succeeded, for in spite of its covering of brick or stone a steel-frame building can generally be recognised by the slenderness of its columns and the size of the spans, often over large areas of plate-glass windows. The great advantage of steel in building is that it allows of slender members carrying great weight, with consequent economies in floor space and materials. Thus its slenderness is the principal characteristic of steel compared with other building materials, and logically the thinner the members in a steel frame building the more truly the elevation expresses the material of which it is constructed. We see this carried to extremes in a few factory buildings, of the " daylight " type, with very thin columns and girders and a maximum of window space. But although it is generally agreed that this type of building expresses both its function and the material of which it is made and may therefore be good architecture, the same design would be totally unsuited for a monumental building or a block of offices. Therefore the steel skeleton is covered with stone or brick until it approximates in size to a frame-work that would be structurally sound if it were built of solid stone or brick and the steel omitted altogether.

In reinforced concrete almost the same factors are seen to affect design. The members of a reinforced concrete frame that give maximum economy need be hardly any larger than in the case of a steel frame building. Buildings with such thin members have been built, and criticised architecturally because of their " thin and skimpy " appearance. In both steel and reinforced concrete the architect has to find the happy medium between the thin members that stand for economy and the heavier members that, beyond the covering necessary for fireproofing, add to cost without increasing the strength or durability of the building. It seems that the advent of these new materials has forced the architect into the position of adding structurally unnecessary materials in order to produce a building that will appear structurally sound. If he makes use of the strength of modern materials and gives the building owner the large unbroken window space he desires by spanning a large sheet of plate-glass he is criticised on the ground that, however strong the construction may be in fact, it does not look strong. If he break up the window space with columns that add to the cost unnecessarily so far as structural soundness is concerned, he produces a building that looks strong, but only by putting the owner to unnecessary expense and, presumably, against his own conscience when he realises that he is wasting materials. It seems the only rational way to look at the problem is a frank realisation of the fact that hanging stone to a steel or reinforced concrete frame is simply decoration added to conform to tradition as to what is good proportion in other materials, and to consider the extra cost amongst the "trimmings."

These thoughts are prompted by the publication of a sumptuous volume entitled "Architectural Design in Concrete,"* which is, we believe, the first published record on a large scale of examples of reinforced concrete design from all over the world. The book contains 100 plates in half-tone, and the subjects range from working-class cottages to American skyscrapers. A study of these plates is of very great interest, but they do not seem to take us much farther in the solution of the problem, What is a suitable style for reinforced concrete? The buildings illustrated, with the exception of two or three, could have been built in any other material so far as appearance is concerned. We are shown skyscrapers and office blocks that have their counterparts elsewhere in steel frame; there are schools and other buildings of classic design that we can hardly believe are concrete so stone-like do they look; traceried windows that might have been of stone if funds had not been limited; we see big industrial structures, with large blank wall spaces, that remind us of ancient Egyptian buildings, or our own Martello Towers, built of brick; houses that cannot be distinguished from stuccoed brick. A style that truly expresses a new material should not remind us of anything that has been done before in another material; it should express itself, so that one would without hesitation say, "That is a reinforced concrete building." The two or three exceptions referred to can only be classed as freak buildings, such as a restaurant in Germany built over an old fort with a huge cantilevered upper story.

This collection of photographs, in our opinion, proves two things. The first is that so far there is no sign of a definite and unmistakable "concrete style," and second that reinforced concrete may without hesitation be used for any type of building and in any style. They prove that in reinforced concrete we have a material of such versatility that it can be used in place of any other building material or combination of materials. With natural stone aggregate and ordinary methods of tooling it is indistinguishable from the stone of which it is made. It may be stuccoed like brickwork, or colour washed. Even common aggregate may be used and afterwards exposed to give an attractive and multi-coloured surface of any colour or texture according to the aggregate selected.

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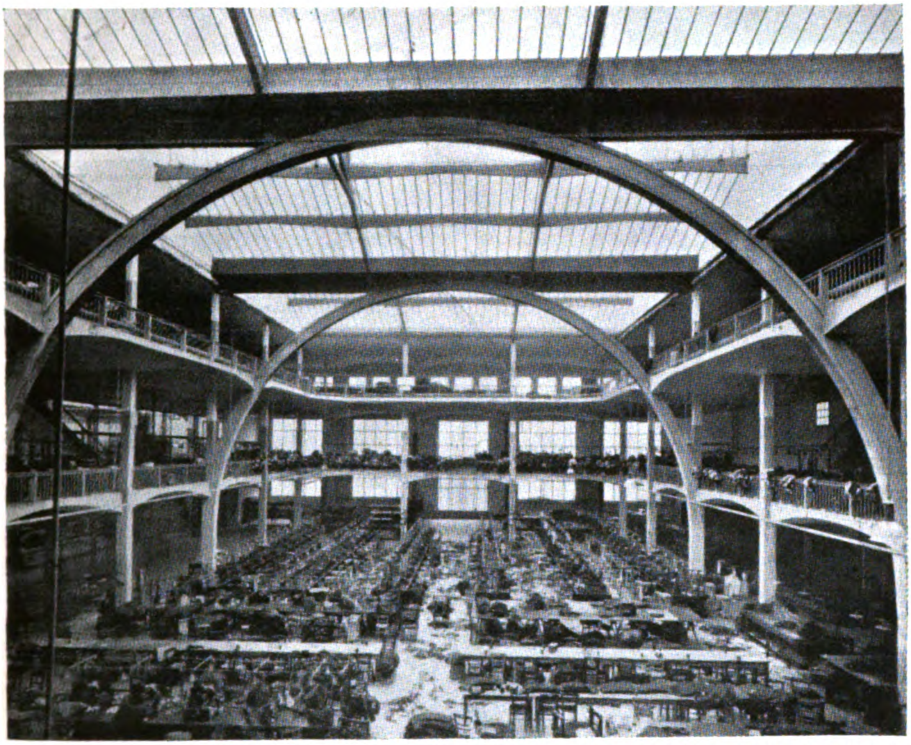
* "Architectural Design in Concrete." By T. P. Bennett, F.R.I.B.A., with photographs by F. R. Yerbury. (London: Benn Brothers, Ltd. Price 30s. net.)



From "Architectural Design in Concrete."

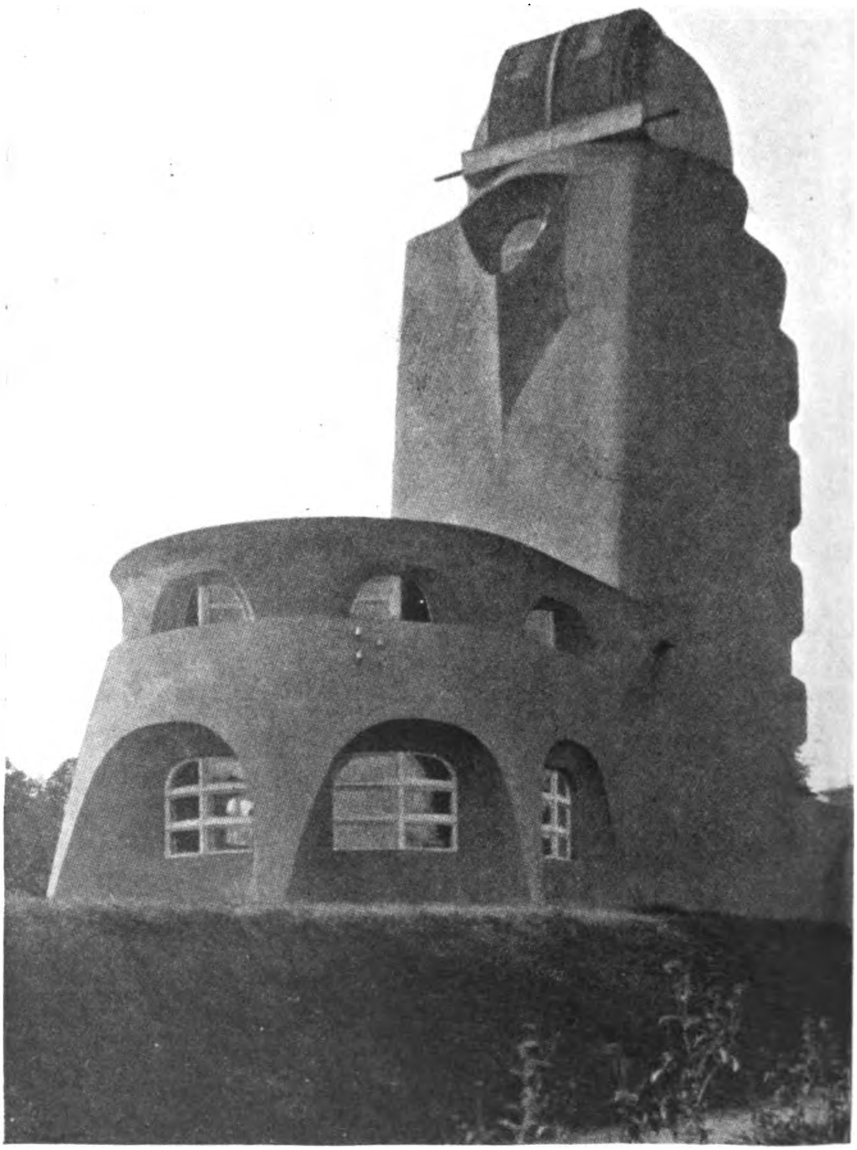
Interior of a Factory Building at Paris. MM. A. & G. Peret, Architects.

The photographs are prefaced by some notes which hardly do justice to the subject. For instance, methods of surface treatment are dealt with at some length, but no mention is made of the bush-hammer, or the use of coloured cements. Crazing of cast stone is referred to, and it is stated that "a thin coat of stucco or roughcast will probably overcome the difficulty"; far better to use a fairly lean mix for the face, properly grade the sand, be sparing with the water content, pay attention to curing, and thus prevent crazing, as it can be prevented.

We hope the volume will reach the hands of every architect, so that the extent to which reinforced concrete is being used, and the diversity of its applications, will be thoroughly realised.

Concrete Bridges and Æsthetics.

In view of the present suggestion that at least one of the new bridges to be built across the Thames should be in reinforced concrete, the following remarks of Col. Ashley, the Minister of Transport, made in the House of Commons, are worth putting on record. He said: "On the question of new bridges, I am very anxious, extremely anxious, that in 200 years' time our descendants shall not make



From "Architectural Design in Concrete."

The Einstein Tower, Potsdam. Erich Mendelsohn, Architect. (*See p.* 409).

disparaging remarks of the bridges we have built during these few years. We have had some extraordinarily fine bridges handed down to us, and it is up to us to see that the next generation has bridges worthy of us. Anyone who has been to Berwick-on-Tweed will see a fine bridge rising there of reinforced concrete, with a span of 365 ft., the biggest concrete span in the country, which will be opened in November or December, and which will be a landmark, and a beautiful landmark, across the river which divides England and Scotland." This opinion on the suitability of concrete for the construction of important bridges gives official backing to the recent statements of Mr. H. V. Lanchester, F.R.I.B.A., and other architects at the Royal Institute of British Architects recently, when the æsthetic value of concrete for bridges was stressed.

Supplying Ready-Mixed Concrete.

WE have previously referred to the experiment started in the United States two or three years ago of supplying ready-mixed concrete from a central mixing plant. It was found possible to haul the concrete by lorry for distances up to forty miles with satisfactory results, and after a few experimental stations had been set up there was sufficient demand from local contractors to justify extending the idea. The concrete was principally used on road works, and by contractors who found it more convenient or cheaper to buy concrete ready mixed rather than instal their own mixing plant.

The success achieved by one of these ready-mixed concrete depots is shown by the published figures relating to a plant at Birmingham, Alabama. The plant commenced operating in 1924. During 1925 the output was 70,000 cubic yards of mixed concrete. In 1926 it increased to 100,000 cubic yards; in one day last year 814 cubic yards of mixed concrete was supplied from this plant. The plant makes use of two mixers, one of 1-cubic yard capacity and one of 2-cubic yards capacity. Two standard mixes are supplied, and any proportioning or special aggregates are mixed to order. The average length of haul is about 9 miles from the plant, and it is stated that no appreciable segregation of the material has been noticed, although this is probably due to the fact that slag, which is nearly equal in weight to sand and cement, is generally used. We gather that other of these ready-mixed concrete depots are doing equally as well.

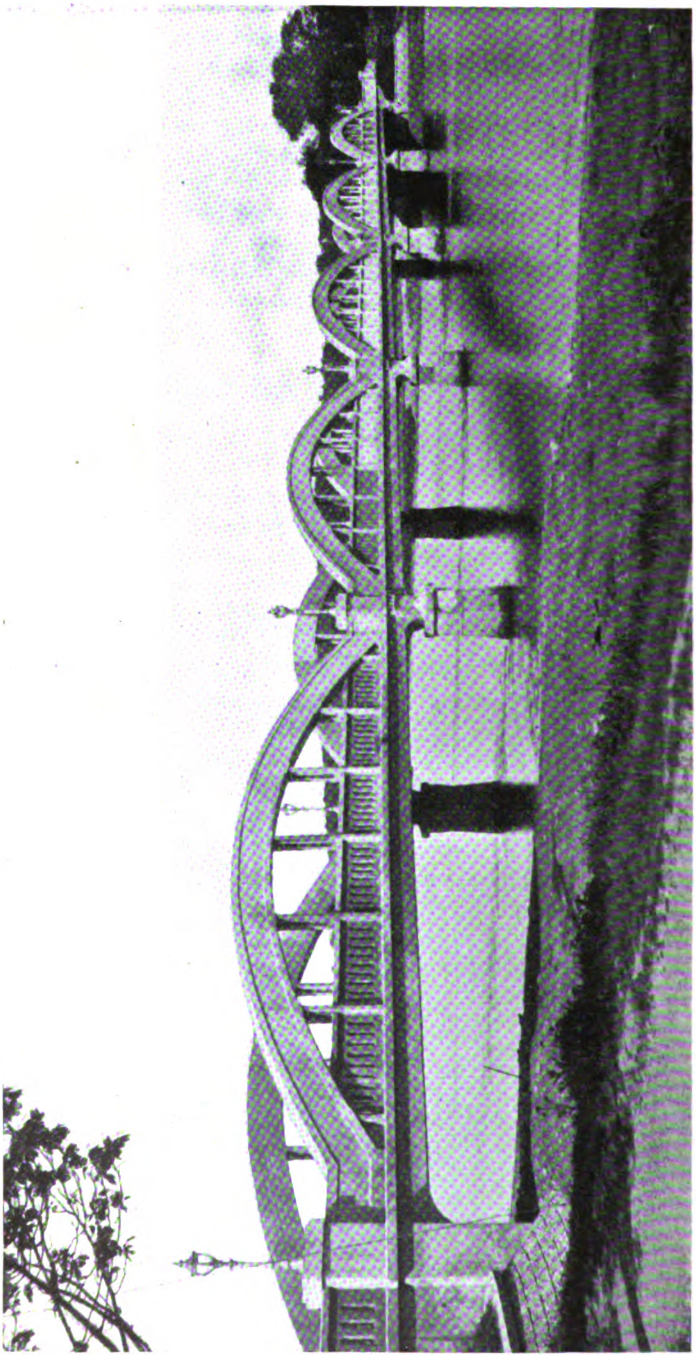


Fig. 1.—Reinforced Concrete Bridge at Kirkcudbright. (*See p.* 415.)

Reinforced Concrete Bridge at Kirkcudbright.

By CHARLES V. WOLFF, B.Sc.

SHORTLY after the opening of the railway to Kirkcudbright, in the middle of last century, a bridge was constructed across the estuary of the river Dee to link up the town with the large agricultural district lying to its north and west. This bridge, which was opened in 1868, was of a very light form of construction, although quite strong enough to carry the traffic of those times. It consisted of six iron bowstring spans, the supporting piers each consisting of two groups of four cast-iron pillars screwed into the bed of the river. One of the centre spans was mounted at its centre on a large cylindrical pier, on which it could be swung so as to permit of traffic passing up and down the river. Actually, however, this opening span was never used in that manner, being kept permanently closed.

Of late years this bridge, like so many others up and down the country, had become altogether inadequate in strength for the purpose of carrying the heavy motor traffic and the rapidly increasing weight of the vehicles using it. As a consequence in 1921 the Southern District Committee of the Stewartry of Kirkcudbright approached the Ministry of Transport on the question of holding an inquiry with a view to the restriction of traffic on the bridge. As a result the Ministry, in 1922, granted the restriction to a 2-ton axle load, and recommended the construction of a new bridge within a period of three years.

After considering various schemes for a new bridge, both in steel and reinforced concrete, the Committee early in 1924 decided to adopt a scheme for a reinforced concrete bridge of five equal bowstring girder spans. This type of bridge was called for by the fact that at high water (ordinary spring tides) there is only a headroom of about 5 ft. under the soffits of the bowstring girders, and about 7 ft. 6 in. between high water and road levels.

The general particulars of the new reinforced concrete bridge are shown in *Figs*. 3 and 4. The length of each of the spans is approximately 88 ft. 9 in. measured between the centres of the piers; the total length between the centres of the abutment piers is 444 ft., and the total length over the approach retaining walls 511 ft. The bridge is 26 ft. 6 in. wide between the bowstring girders, with a carriageway 20 ft. wide, and a footpath 5 ft. wide on the downstream side of the bridge. The roadway is level over the whole length of the bridge, and at the centre of the stream is about 42 ft. above the river bed.

Bore holes, sunk before the commencement of constructional operations, showed the river bed to consist of soft sandy mud or silt for a depth of about 4 ft. in the centre of the river and as much as 25 ft. at the sides. Below this there is a bed of very soft blue clay and then a bed of hard bound gravel varying from 4 ft. to 7 ft. thick. Underneath this bed is a fine reddish clay which extends to a depth of over 70 ft., at which level the borings ceased.

A consideration of the nature of these underlying strata, as revealed by the borings, seemed to indicate that it might be practicable to adopt a system of reinforced concrete piles, driven in groups, for the foundations to the abutments and river piers. A scheme was accordingly prepared on these lines, and the contract for the work was let to Messrs. John Angus & Sons, of Edinburgh, in 1924. Work was immediately commenced by the driving of trial piles.

It soon became evident from the results of the driving of these trial piles that, contrary to expectation, it would be impossible to rely on piles for the purpose of carrying any appreciable load, as those which were driven penetrated to a great depth without showing any signs of reaching the requisite set.

In preference to the alternative of using a very large number of piles—a solution which would have involved great expense not only for the piling work but also in the construction of suitable pier bases—it was decided to re-design the foundations both to the abutments and the river piers, adopting foundations of the raft type to distribute the load at a moderate rate over a large area.

The rafts under the abutments are 38 ft. by 12 ft. in plan, each being anchored by eight 14-in. by 14-in. rein-

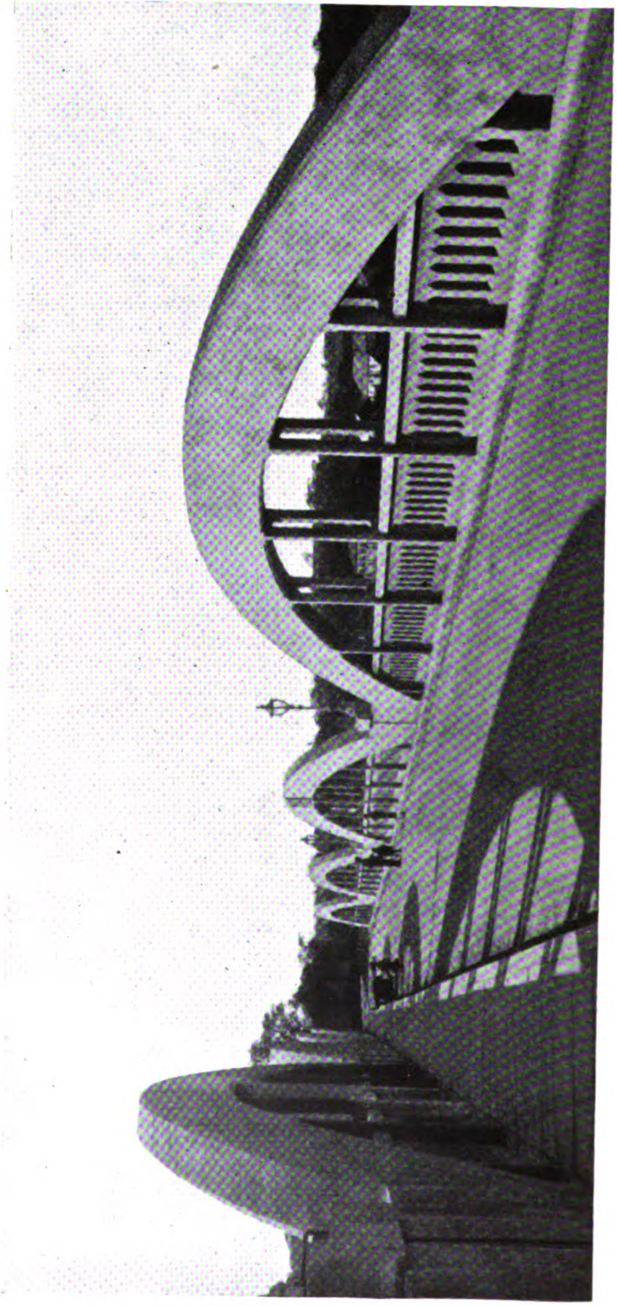
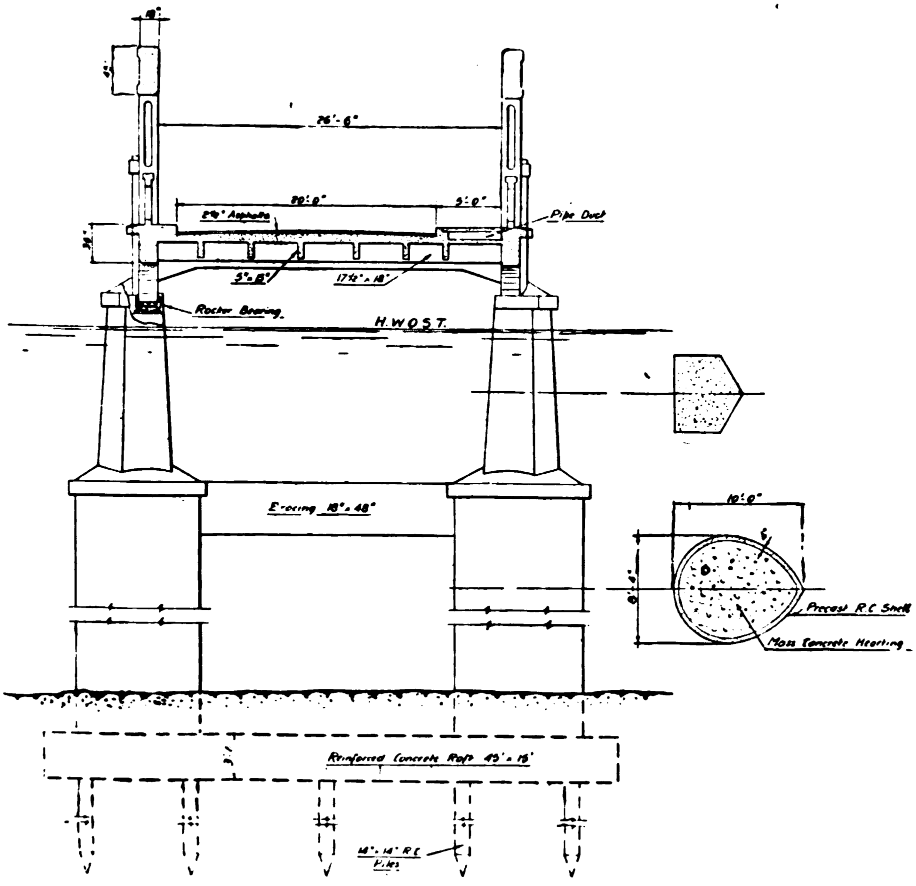


Fig. 2.—Reinforced Concrete Bridge at Kirkcudbright.

forced concrete piles. They rest at a level about 20 ft. below road level. These rafts are of slab and beam construction. The load from the end columns, which carry the bowstring girders, is distributed over the raft by means of the abutment curtain wall, the lower portion of which acts as an immensely stiff vertical beam, in addition to retaining the filling behind it. This part of the curtain wall is 10 in. thick and stiffened by large counterforts which distribute the load through beams to the raft slab, which is 8 in. thick.

The rafts supporting the river piers are each 45 ft. by 15 ft., and are solid slabs of concrete of a uniform thickness of 3 ft. 6 in., this simple form of construction being adopted as most suitable where the work had to be carried out in cofferdams. The rafts are heavily reinforced, and each is anchored by fourteen 14-in. by 14-in. reinforced concrete piles, with the exception of the first pier from the Kirkcudbright end of the bridge where such a good bottom was found on the bed of hard bound gravel that it was thought unnecessary to provide this anchorage.

From these rafts rise the columns, a pair of which form each of the piers. From their bases, where they are anchored



— CROSS SECTION —

Fig. 3.

to the raft, up to a level about 20 ft. below road level, these columns are entirely independent. They are pear-shape in section, and measure 10 ft. in the direction of the stream by 8 ft. 4 in. in the transverse direction. At the level referred to, viz. 20 ft. below road level, they are connected by a strong horizontal bracing which is 48 in. deep by 18 in. wide. This part of the columns is built up of pre-cast reinforced concrete shells, 4 in. in thickness, and constructed in lengths convenient for handling. These shells were built up by adding successive rings to the requisite height, and the core filled with concrete hearting suitably reinforced. As may be seen from *Fig.* 3 the columns are so disposed as to act as cutwaters both with an ebbing and a flowing tide.

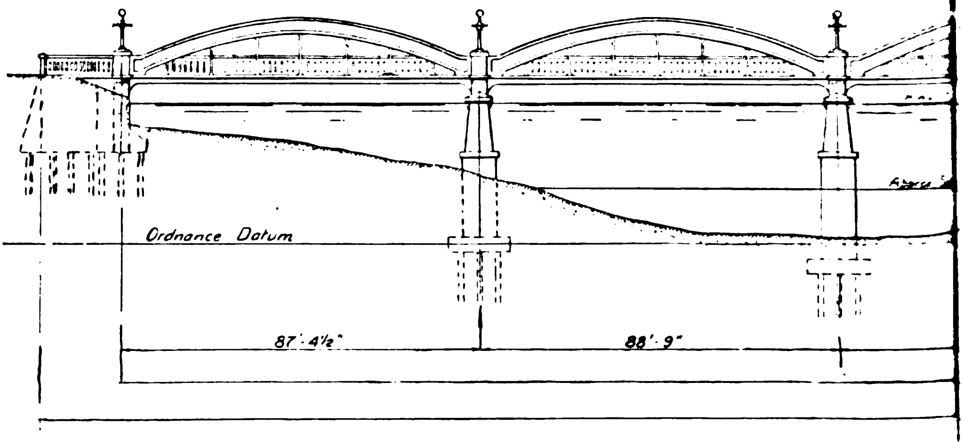


Fig. 4.—REINFORCED

The whole of the work on the river pier rafts and the lower portion of the columns had to be carried out in cofferdams, which were constructed of steel sheet piling. Considerable difficulties had to be faced in the construction of these cofferdams, and subsequently in keeping them sufficiently watertight, owing to the great depth of water, which in the centre is as much as 35 ft. at high water, the tide having the great range, at ordinary spring tides, of 24 ft.

The caps on the heads of the lower portions of the columns are about 17 ft. below the soffit of the bowstring girders, or about midway between high- and low-water levels. From them rise the tapered columns which carry the bowstring bearings. These columns are pentagonal in section, so as to act as cutwaters, their overall size tapering from 7 ft. by 6 ft. at the base to 5 ft. by 4 ft. 5 in. at the top, where a head is formed to receive the bearing plates for the bowstrings. The two columns forming the upper part of the pier are not braced together in any way, although the bowstring spans themselves act as ties at the top.

Reference must be made to the special form of bearings used in the bridge. Each span of the bridge is an entirely separate unit, with bitumen expansion joints between each span, and between the end spans and the abutments; in addition, each bowstring girder rests on a cast-steel rocker expansion bearing at each end. The result is that any possible unequal settlement of the supports, and also expansions and contractions, can be taken up without damaging or straining any part of the superstructure or causing unsightly cracks to be produced. These bearings are illustrated by *Fig.* 5, which shows one of the bearings on the river piers; those at the abutments follow a similar design. The lower massive bearing plate is of cast steel and has a flat machined upper face, being bolted down on to the head of the pier column. The upper shoe has a machined cylindrical under surface which rests on the lower plate. This shoe is also of cast steel and is securely fastened to the end of the bowstring girder. These bearings, and also the joints between the spans, are masked from view by the pilasters placed over the piers.

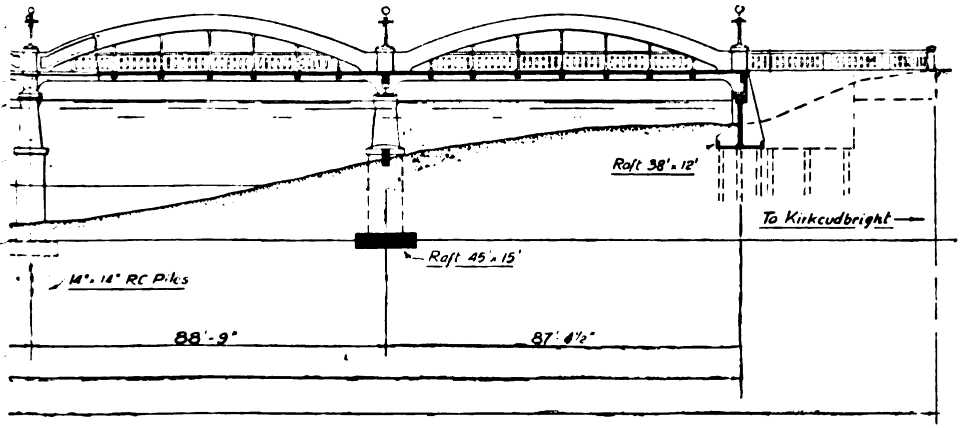
The bowstring girders have a span measured between the centres of the bearing shoes of approximately 86 ft. 8 in., and a rise of 13 ft. 6 in. The bottom booms have a section 18 in. wide by 36 in. deep, and are reinforced with 20 bars 1¼-in. diameter. The top booms are 18 in. wide by 45 in. deep and are reinforced with 24 bars 1⅜-in. diameter at the maximum section. The vertical members are spaced 11 ft. apart, and have a section of 7 in. by 18 in. reinforced with 4 bars 1⅝-in. diameter. These are attached to the ends of the cross-beams under the decking and act as suspension members to transmit the dead and live loads of the roadway to the arched top booms.

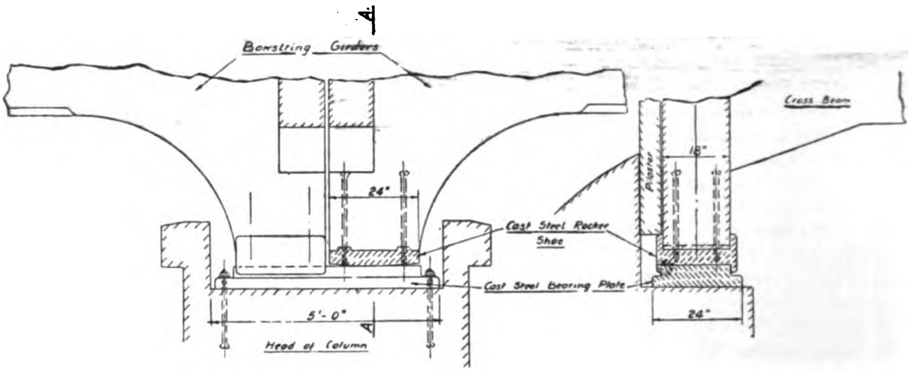
There is no wind bracing provided between the top booms of the bowstrings, as the small rise rendered this impossible from the point of view of headroom even if it were desirable ; such bracing is not required in this case, as the wind moments are fully provided for by the lateral stiffness of the vertical members, which are rigidly connected to the cross-beams of the decking.

The roadway is formed of 2½ in. of asphalte laid direct on the reinforced concrete decking, which is cambered on the upper surface only, being 6½ in. thick at the sides and 8½ in. thick at the centre of the roadway. This decking rests on longitudinal secondary beams (scantling 5 in. by 15 in.) which in turn rest on the cross-beams (17½ in. wide by 18 in. deep) spaced 11 ft. apart. The rather uneconomical proportions of these beams is due entirely to the fact that the available constructional depth was extremely limited, the total permissible depth from soffit of main girders to upper surface of decking slab at the crown of the road being only 2 ft. 4½ in.

A pipe duct is formed under the footpath, covered with pre-cast reinforced concrete slabs 4 in. thick, provided with a granolithic finish. The kerbs are also of concrete, monolithic with the decking and provided with a granolithic wearing surface. The parapet both to bridge and approach walls is of reinforced concrete of a pierced design.

The approach walls at the ends of the





Side Elevation & Part Section

Section on A-A

Detail of Rocker Expansion Bearing

Fig. 5.

bridge are, for the most part, taken down to the same level as the abutment foundations. They rest on large bases designed to give a small, and as far as possible uniform, load on the ground, and reinforced concrete piles are used for anchorage purposes. The curved walls at the extreme east end, having only a very small depth of filling to retain, are only taken down to a relatively small depth.

The bridge occupies practically the same site as its predecessor, and the first operation carried out by the contractor was the removal of three spans of the iron bridge, following which heavy timber piles were driven to carry a temporary bridge and to support the staging for the new bridge. The removal of the cylinder which supported the opening span of the iron bridge caused considerable delay and difficulty, but this was successfully floated out of position, the site being now occupied by one of the pier rafts.

The work was completed towards the end of 1926, and the official tests carried out with trains of the heaviest available vehicles were extremely satisfactory, the deflections recorded under the severest possible conditions being very minute. The bridge was formally opened on November 19, 1926. The structure is designed to carry the Ministry of Transport standard loading.

The consulting engineers were Messrs. Blyth & Blyth of 135 George Street, Edinburgh ; the reinforced concrete work is to the designs of Messrs. L. G. Mouchel & Partners, Ltd., of 38 Victoria Street, Westminster ; the contractors were Messrs. John Angus & Sons, of Edinburgh.

Department of Scientific and Industrial Research.

Sir Richard Tetley Glazebrook, K.C.B., F.R.S., has been appointed a member of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.

Messrs. Carreras' New Factory, Mornington Crescent, London.

LONDON'S LARGEST REINFORCED CONCRETE BUILDING.

By W. L. SCOTT, M.Inst.C.E.

THIS building, which is being constructed for the manufacture of cigarettes, will contain machinery and other equipment of the most original and modern types. The structure itself will be entirely of reinforced concrete, including the main chimney shaft, and the architectural treatment is pre-eminently suited to this material. The elevations of the building are designed on an early Egyptian model treated conventionally to comply with modern requirements, and having as a central feature on the main frontage columns 5 ft. 3 in. diameter by 47 ft. high, with a large ornamental cornice, all formed with coloured concretes.

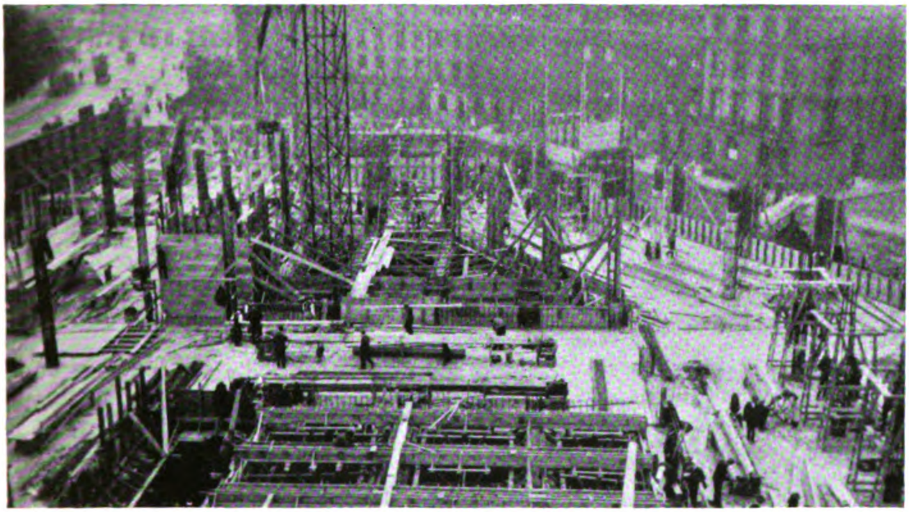


Fig. 1.—General View of Ground Floor Construction, Looking South.

The Company's well-known "Black Cat" trade mark led the architects to decide on erecting a building having early historic connections with the worship of the cat. Cats' heads and other decorative features are incorporated in the design, all in concrete, some deposited *in situ* and some pre-cast.

An inspection of the main elevation (*Fig.* 2) indicates that the building will have an artistic character entirely its own, and although the style is of archaic derivation it is fully indicative of its modern use. The proprietors decided to erect an ornamental building in order to conduce to the brightening of a somewhat drab neighbourhood, and their kindly intentions have been developed on lines which should compare favourably with the most recent large City office buildings and the most up-to-date West End stores. No reinforced concrete

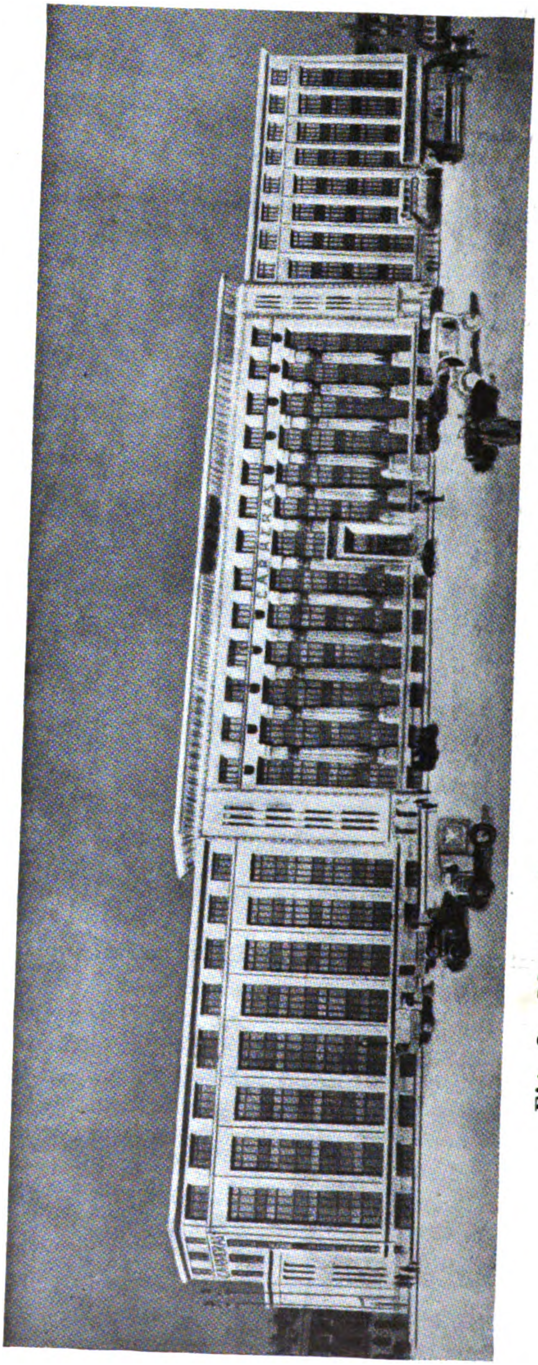


Fig. 2.—Messrs. Carreras' New Premises, Mornington Crescent.

building with such extensive and detailed architectural treatment has before been attempted in this country, and very few abroad.

The elevation fronting Hampstead Road is about 550 ft. long by 80 ft. high above pavement level. The main external faces of the building are rendered with white Portland cement and coloured sand giving a warm Eastern stone finish, the highly coloured work being introduced as main features and points of interest.

As is well known, great precautions are very necessary if such rendering is to be without defect; in fact, if carelessly done it is most unsightly, as is unfortunately evidenced by too many examples to be seen in London. In an endeavour to secure success, continuous experiments have been and are still being carried out, and it is hoped that a perfect result may be ultimately secured.

A great many problems have inevitably arisen in a pioneer work such as this. For example, the production of coloured concretes that will be permanent and will stand the test both of time and London atmosphere, as also the insertion or attachment of the pre-cast pieces (sometimes weighing upwards of a ton) to the *in situ* concretes, are all problems that have been now successfully overcome.

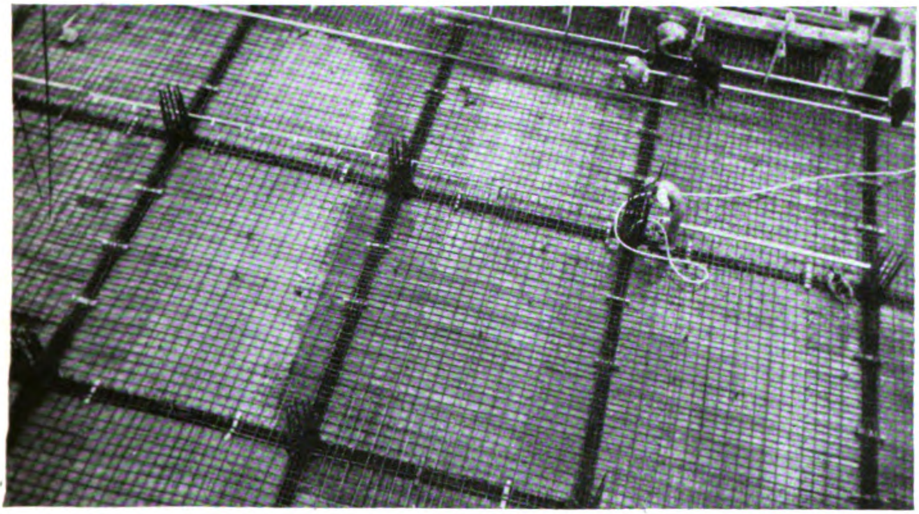


Fig. 3.—View of Floor Reinforcement.

Some indication of the interior accommodation is given by the fact that the total floor space available is about nine acres, or approximately 392,000 sq. ft. This huge area is secured on basement, ground, first, second, third, and fourth floors. A flat roof, upon which are erected water tanks, air conditioning rooms, etc., and capable of being flooded during great heat, will cover the building.

Figs. 1, 3 and 4 show the work in course of construction. The floors have been divided into large panels, with the supporting beams spaced at 17 ft. in the longitudinal direction and 18 ft. transversely. The interior of the building is separated by transverse walls into three sections, known as North, South and

Central. At each of these division walls expansion joints are formed above the level of the ground floor, so as to separate completely the three sections one from another. The expansion joints were deemed desirable, both by reason of the length of the building and the rapidity with which the work is being erected. The internal columns, numbering 260, are mostly octagonal in section, and are spirally reinforced on the Considère principle.

The exposed surface of the interior work is being rubbed down with soft stone and cement grout as soon as practicable after the removal of the timber shuttering, to form a smooth aseptic finish. The official departments, including offices, board room, etc., as also the health departments and housekeeper's residence, etc., will be plastered, tiled and decorated to harmonise with the Egyptian character of the exterior.

There are approximately 24,000 cubic yards of reinforced concrete and 2,500 tons of steel rods required for this work. The weight of the aggregates required for concrete will amount to about 70,000 tons, and 7,500 tons of cement will be required. All these materials have to be handled in a period of about nine months.

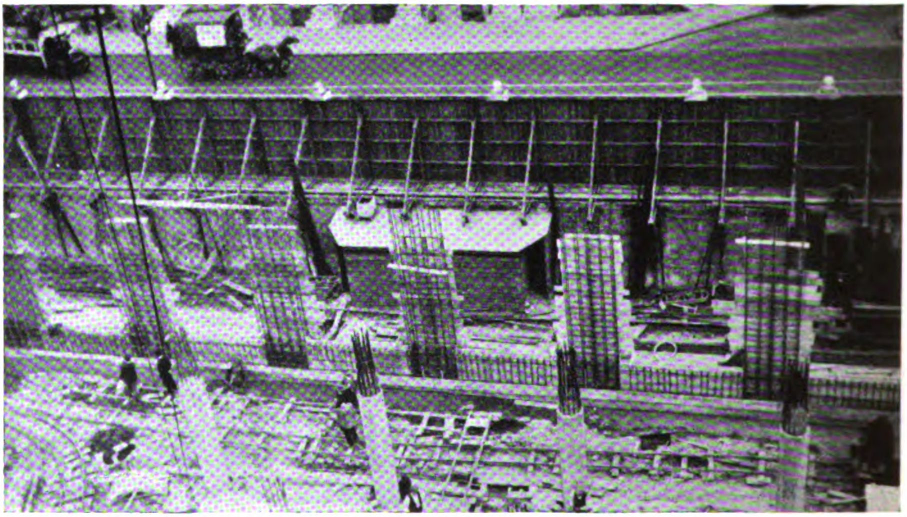


Fig. 4.—View of Main Piers to Hampstead Road Front.

To expedite construction, rapid-hardening Portland cement concrete is being used for the floors, while in certain other portions of the work aluminous cement concrete is being employed.

The excavation over the site was dug by a steam digger and loaded into motor transports. The excavation for the foundations is done by hand and loaded into lorries, etc., by steam derricks. All the excavation is removed to spoil; the total quantity will be about 73,000 tons consisting entirely of yellow London clay.

Prior to the commencement of the main building a reinforced concrete retaining wall was constructed around the site. The concrete for this wall was of the aluminous variety, and by its use a large saving in timber work was effected, as well as the elimination of the usual asphalt lining. In this way not only has a saving of many thousands of pounds in the cost of asphalting been realised, but, owing to the construction of the wall being greatly simplified, an even greater saving both in cost and time was effected.

The mixture of concrete adopted for most of the work is 1 : 1½ : 3, the exception to this being most of the internal columns, for which a mix of 1 : 1 : 2 is being used. The proportions adopted for the aluminous cement concrete is 1 : 2 : 4, while the mass concrete in the foundations and elsewhere is generally 1 to 8.

The outstanding plant on the contract consists of three "Insley" placing towers. These are so arranged as to be able to deposit concrete at any point on the building. Each of them will be 160 ft. high when depositing concrete at the level of the roof of the building. The concrete is mixed at the base of each tower in electrically-driven mixers, hoisted and delivered into a hopper, whence it flows in chutes down to its required position. Each of these towers is capable of placing over 100 cubic yards of concrete per day.

The design of the factory has been standardised and simplified as much as possible, and advantage is being taken of this to design the shuttering for repeated use. The total amount of shuttering is about 140,000 square yards (or 30 acres), most of it being 1½-in. timber. The area of external plastering will be about 24,000 square yards, while among the flooring materials required are about 36,000 square yards of maple flooring for factory use.

The entire work has to be completed in 18 months, and it is estimated that the number of men employed in all trades will reach 1,200.

The architects are Messrs. M. E. & O. H. Collins, of 115, Old Broad Street, E.C., assisted by Mr. A. G. Porri of Finsbury Square, E.C. The contractors are Sir Robert McAlpine & Sons, of Pall Mall, S.W. The consulting engineers for the reinforced concrete work are Messrs. Considère Constructions, Ltd., of Westminster, and for heating, air treatment, etc., Mr. Adrian Collins, of Godliman House, Godliman Street, E.C.

Drawn Steel Reinforcement Bars.

THE revision of the British Standard Specification No. 15—1912, "Structural Steel for Bridges and General Building Construction," has been engaging the attention of the Association for some time past, and at the instance of the Institution of Structural Engineers it has been agreed that consideration shall be given to the preparation of a B.S. Specification for Drawn Steel Bars for Reinforced Concrete Construction, which have not up to the present been dealt with by the British Engineering Standards Association.

Dingle Road Bridge, Bristol.

THE engineer for the reinforced concrete bridge at Dingle Road, Bristol (illustrated in our last number), is Mr. L. S. McKenzie, A.M.Inst.C.E., City Engineer of Bristol.

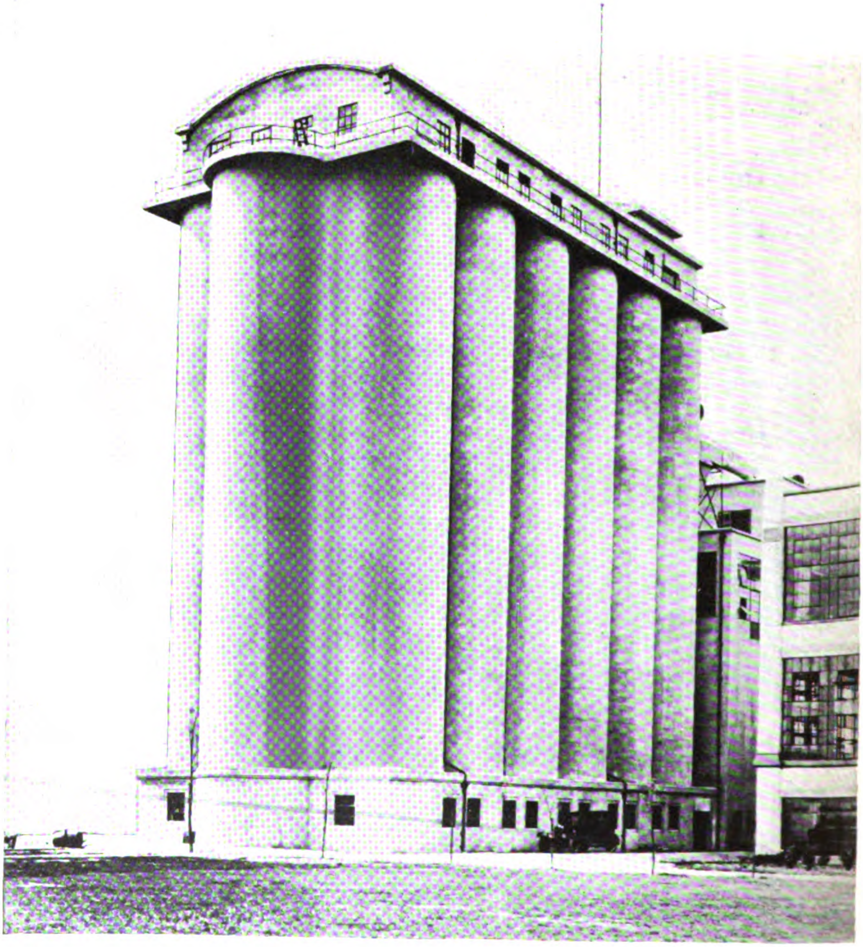


Fig. 1.—Reinforced Concrete Grain Silos at Welwyn Garden City.
(*See p.* 427.)

Reinforced Concrete Grain Silos at Welwyn Garden City.

Rapid Winter Construction—Special Shuttering.

THE reinforced concrete grain silos illustrated herewith are an excellent example of the speed at which reinforced concrete structures may be erected, even under unfavourable weather conditions, when great attention and forethought are given to the planning of the work and to the details of construction. These silos, which have a capacity of about 200,000 bushels, have been built at Welwyn Garden City for the Shredded Wheat Company, and cover an area of 100 ft. 3 in. by 43 ft. by just over 78 ft. in height. The whole of this walling was poured in exactly a fortnight under winter conditions, that is, between December 1 and December 14 last year. A high class Portland cement was used throughout, and this, in conjunction with a system of continuously-moving shuttering, was responsible for what must be a record for this class of construction in this country. Messrs. Peter Lind & Co. (of 2 Central Buildings, Westminster, S.W.1) were the contractors for the whole of the reinforced concrete work and were also responsible for the preparation of the general design and complete details in collaboration with the main contractors (Messrs. Thomas Robinson & Son, Ltd., milling engineers, Rochdale, who were responsible for the lay-out of the building, supply and installation of all machinery and plant), and are to be congratulated on proving the very great rapidity with which reinforced concrete buildings may be erected with up-to-date methods and modern materials.

The more general use of rapid-hardening cement has greatly facilitated the speeding-up of certain special forms of concrete work, but there still remains the difficulty of shuttering when an engineer or contractor is compelled to work against time on a reinforced concrete building. Standard steel shuttering, and special collapsible forms, have assisted in certain special cases in the same manner as rapid-hardening cement has helped in other cases, but the necessity of erecting, stripping, and cleaning the forms has with few exceptions invariably entailed delay.

It is therefore interesting to have evidence that this very real difficulty of shuttering delay has been successfully overcome in the case of these silos, in which the main problem consisted of the shuttering for the silo walls.

It will be seen from *Fig.* 2 that the battery of silos consists of eighteen hexagonal bins with curved external walls, providing an approximation to the economical circular bin shape without involving the dead space which results from the use of circular bins in such a battery.

As the silo walls are nearly 80 ft. high, and involve approximately 10,000 sq. yds. of shuttering, obviously a satisfactory solution of the shuttering problem was of vital importance to the progress of the work. The solution of the difficulty was found by the adoption of continuously-moving shuttering which can be adapted to any shape of bin without undue complications, a method that has been quite extensively used in America.

The general principle underlying this form of shuttering is that of continuous progress. A belt of shuttering to the required shape, and very rigidly braced, is constructed to a height of about 4 ft. from the starting level of the walls. The shutters have a taper of ¼ in., giving ⅛ in. clear on each face at the leaving edge at the bottom. A working platform is constructed on top of these shutters, and this rises automatically as the shutters are raised.

The forms are suspended from a series of jacks attached to the bracings around the shutters at such positions as to give an even lift to the whole of the shuttering system when the jacks are screwed up. These jacks engage with sockets of mild steel pipes projecting from the concrete, which are in turn locked by the insertion of steel rods as work proceeds (see *Fig.* 7). By a continuous process of jacking, the shuttering system is raised as the concreting proceeds. When the jack is screwed out almost to its limit, a short length of locking bar, followed by a pipe to surround it, is inserted in the pipe socket which has been utilised by the

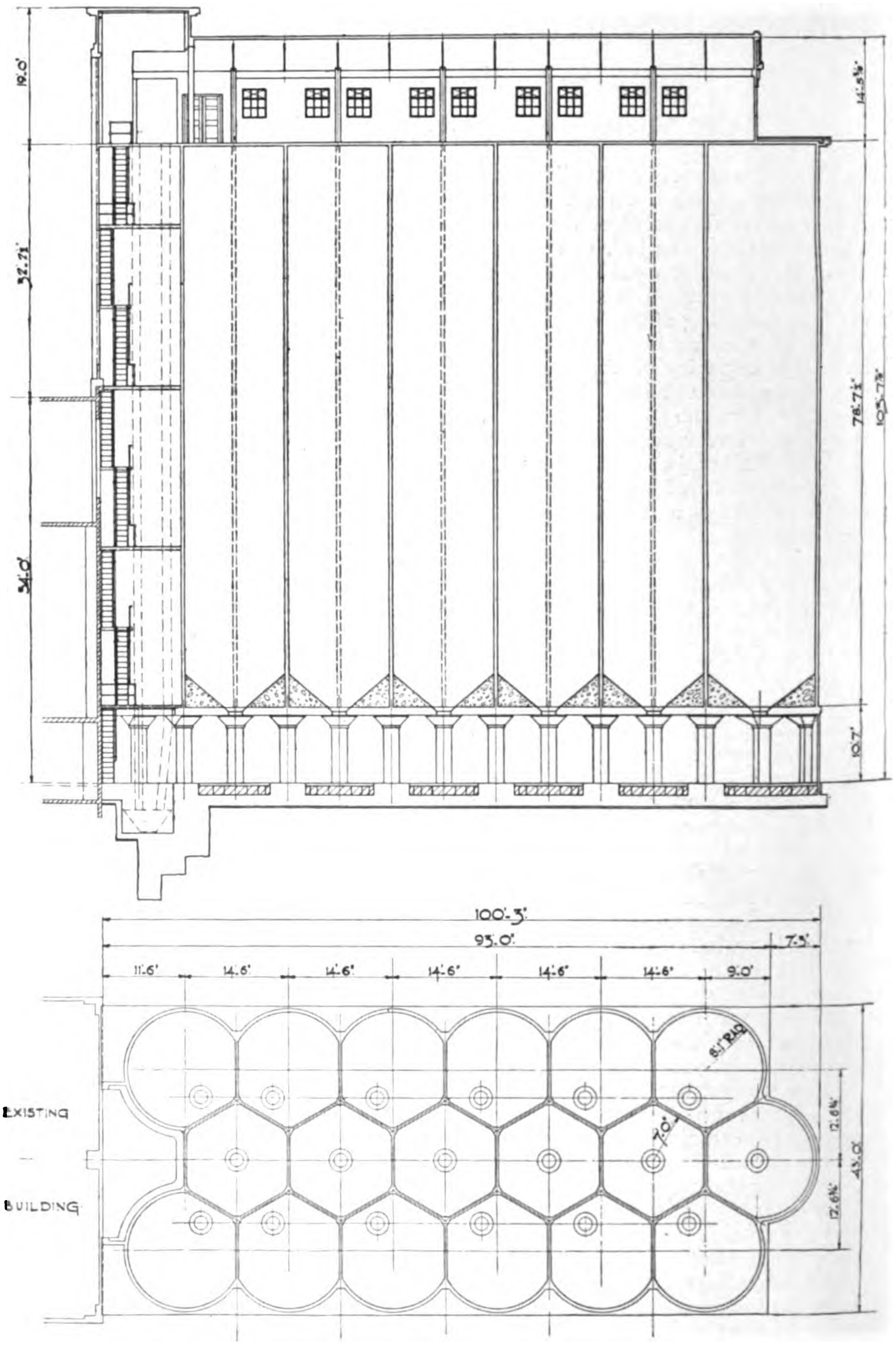


Fig. 2.—Plan and Section: Grain Silos at Welwyn Garden City.

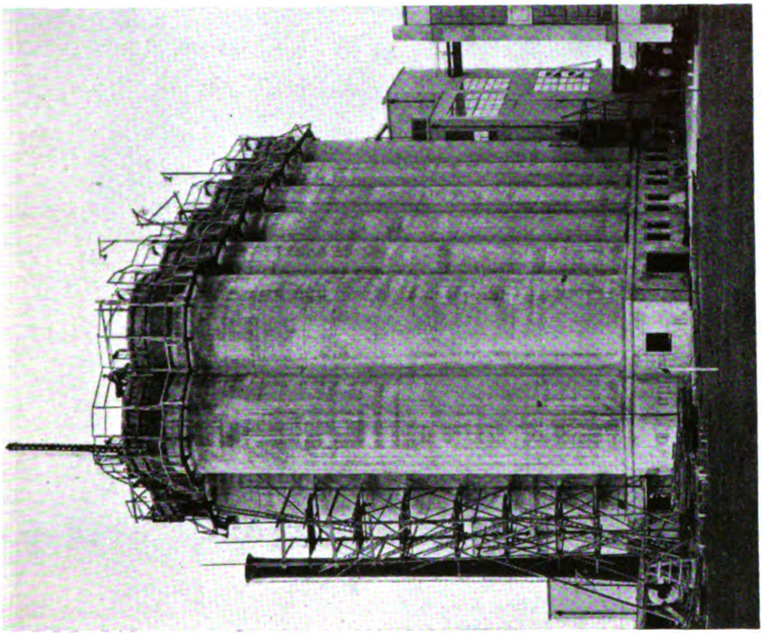


Fig. 4.—Progress View, December 16.

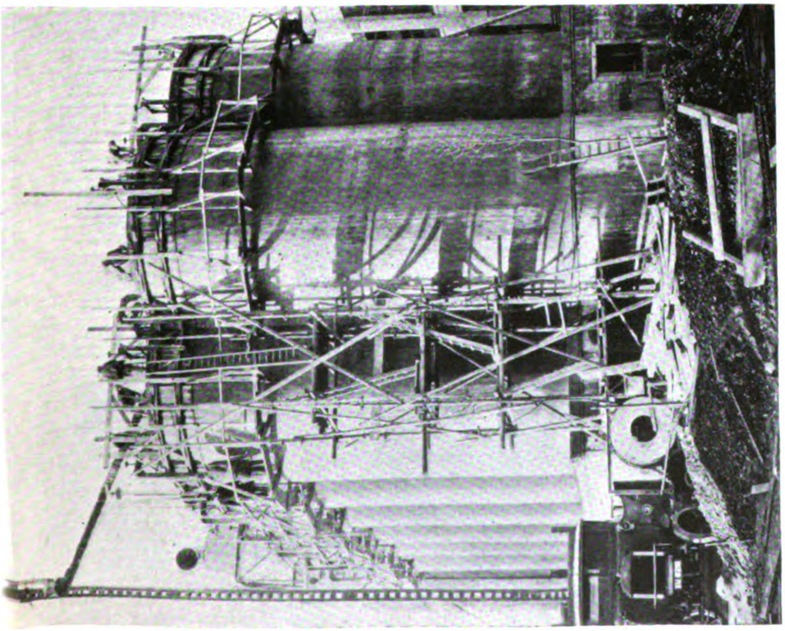


Fig. 3.—Progress View, December 9.

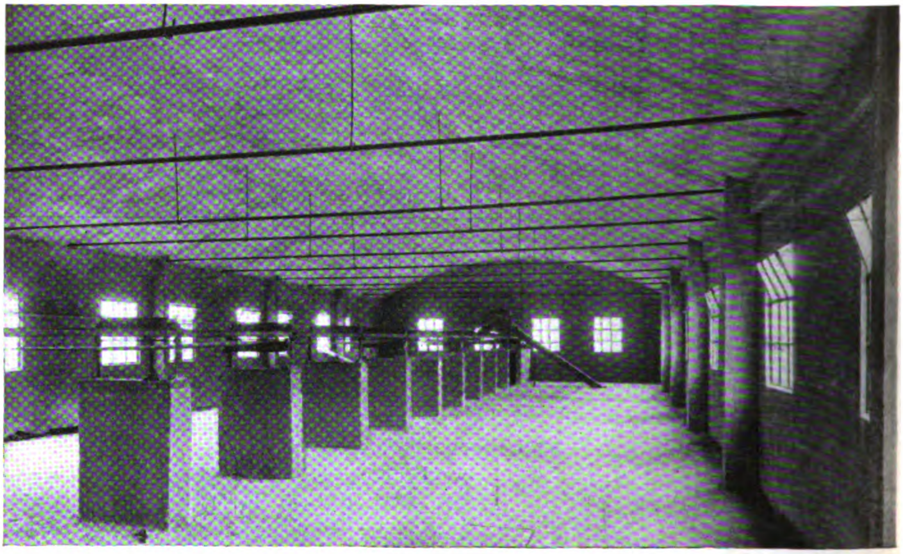


Fig. 5.—Distributing Conveyor in Top Chamber.

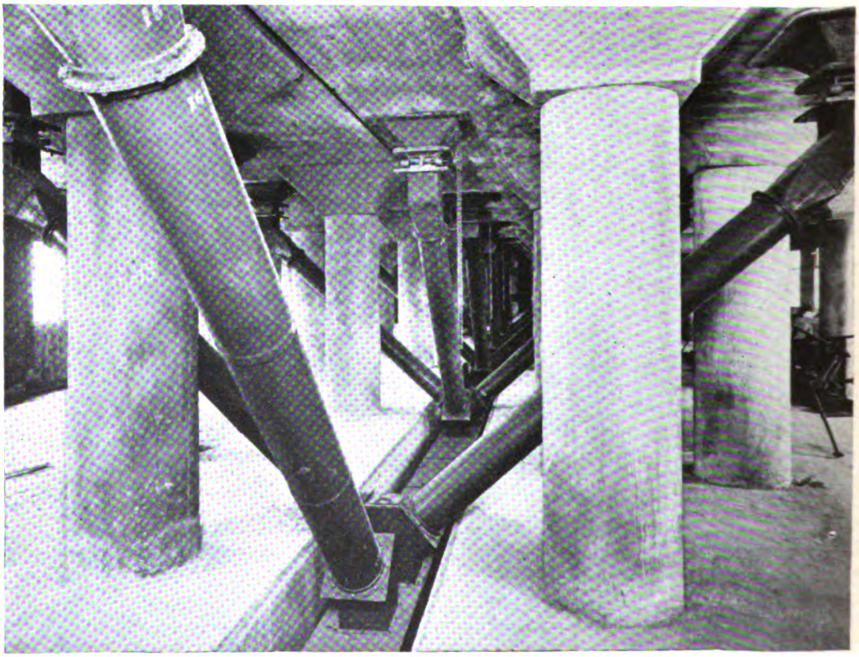


Fig. 6.—Outlet Chutes in Bottom Chamber.

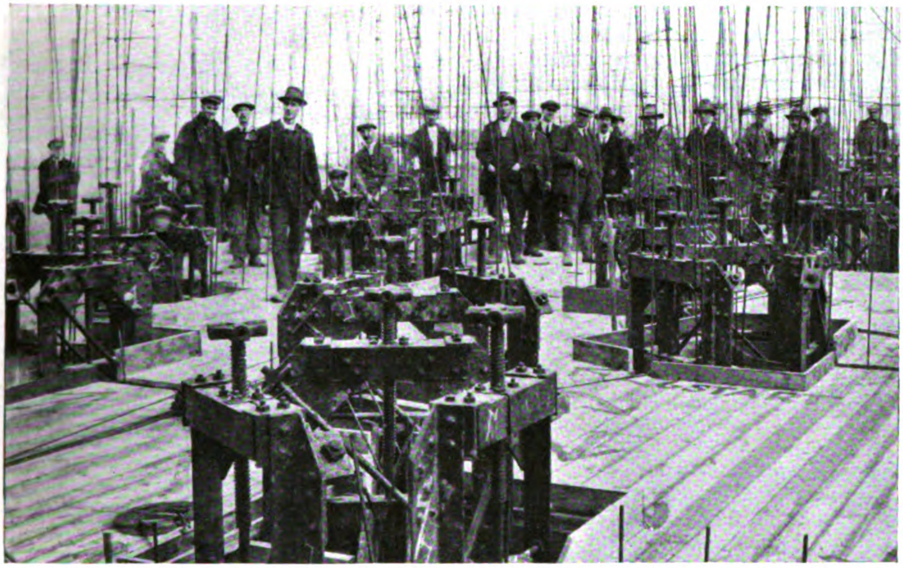


Fig. 7.—Jacks for Operating Continuously-Moving Forms and the Working Platform.

first jacking operation. For this purpose each jack is screwed back in turn to permit the lengthening of the sockets; the jack is then re-engaged in the lengthened socket, and jacking proceeds again. By arranging a definite rate of screwing up the jacks, the speed of jacking can be very closely related to the maximum output of concrete. In this instance one jack operator was responsible for ten jacks, and it was found possible to carry out continuous jacking at the rate of half-a-turn every three minutes, thus permitting almost continuous pouring of the concrete for the walls. The limitation of speed is arrived at from the rate at which the concrete will set. In this instance the jacks were worked so as to permit progress at an average rate of 5 ft. 8 in. in 24 hours, and no difficulty was experienced. On one or two occasions a height of 6 ft. 6 in. in a 24-hour shift was reached, but it was observed that with the height of shutter used this was the practical limit of speed obtainable at that time of the year—December.

Certain precautions had to be observed to ensure the smooth working of the shutter system, principally in connection with maintaining it in a horizontal plane around the whole of the structure. If the shuttering is permitted to rise one end more than the other, obviously there is a tendency for the shutters to bind on the concrete; if this should happen, and jacking be continued without obtaining the correct level for the system, there is some danger of serious damage to the walls already concreted.

One other point is worthy of note in this method of construction, and that is the necessity for continuous jacking. Only by this means can the shuttering remain self-cleansing. Should it be necessary to vary the rate of concreting the rate of jacking should be varied accordingly.

If these precautions are observed the resulting surfaces are remarkably fine and require very little labour in rubbing down and cement-washing; in fact, a board mark is almost unknown with this system of shuttering.

In addition, it is worth noting that with careful workmanship a perfectly straight and plumb structure is obtained by this type of formwork. In the case of the structure described here, it was not possible to detect any deviation from the vertical.

On account of the disposition of the jacks it will be noted that there is very little clearance for the horizontal reinforcement, and it is impossible to fix this steel more than about 1 ft. higher than the working concrete level. In the design, due regard should be given to simplicity of steel fixing and provision made for at least 1 in. cover to reinforcing bars.

In spite of the cold weather experienced during the period of construction, it was found possible to maintain the continuous concreting required by this system. As already stated, the actual height constructed was nearly 80 ft., and the continuous working period was from December 1 to December 14, or exactly a fortnight. The cement used was slow setting cement to the British Standard Specification.

The plant for the concrete mixing and placing consisted of a ¾-yd. mixer in conjunction with Insley chuting plant discharging into a hopper on the working platform on the shutters previously referred to, from which concrete was drawn off into hand tip-carts and wheeled to the various working parts.

Although these notes are confined to a description of this special example of wheat silo construction, it will be readily perceived that similar methods can be successfully adopted for the rapid construction of any type of silo or similar structures with vertical walls of any considerable height, and that concrete shells for cooling towers of the chimney type would be especially amenable to this form of construction. Experience, combined with rational experiment, should result in even greater efficiency, both in design and construction.

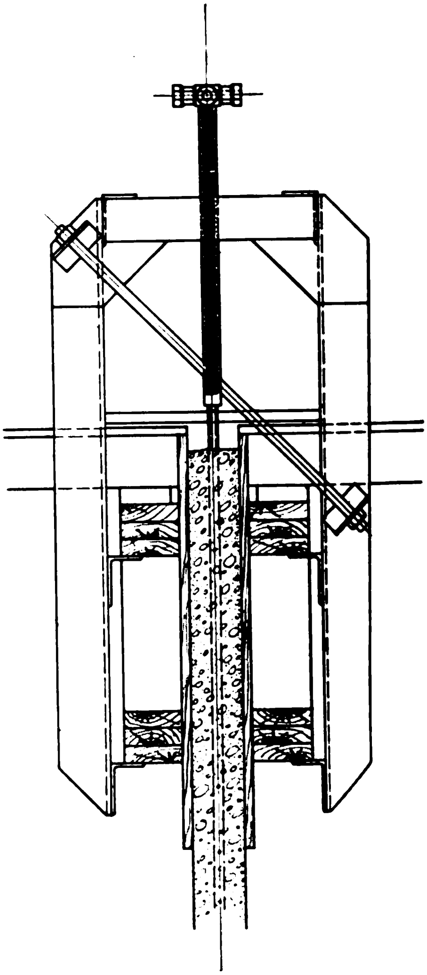


Fig. 8.—Type of Screw-Jack used.

Concrete Sewer Pipes.—A correspondent asks whether a surveyor would give him any information of the earliest use of concrete pipes for sewers or water mains.

Professional Announcement.—Mr. G. Parker Pearson, Chartered Civil Engineer, of Dallas Chambers, Chippenham, has entered into partnership with Mr. H. Ross Hooper, O.B.E., M.A. Oxon., M.Inst.C.E., who has resigned his appointment of Engineering Inspector on the staff of the Ministry of Health. Mr. H. Ross Hooper has for many years conducted inquiries on the various undertakings of local authorities, more especially borough extensions, bridges, and works of sewerage and water supply.

Reinforced Concrete Dairy.

THE Northern Co-operative Society, Ltd., of Aberdeen, are now engaged in the construction of a dairy in Aberdeen to produce 10,000 gallons of pasteurised and bottled milk per day. The building, which measures about 180 ft. by 120 ft., is being constructed of reinforced concrete with rapid-hardening Portland cement.

The pier foundations are of mass concrete with gravel aggregate graded from 1½-in. gauge downwards. The reinforced concrete aggregate is composed of granite chippings from ¾-in. gauge downwards. The pier foundations are set on the hard, but the reinforced concrete floors, which are not connected to the walls, are laid on made ground on a bed of mass concrete 4 in. thick. All foundations are designed for a safe bearing of 1 ton per sq. ft.

To eliminate columns in the working floor areas, which are undesirable in a milk-handling factory, long spans were introduced. Some of the beams are of 62 ft. clear span. The north and south wings have flat reinforced concrete roofs covered with asphalte. The centre wing has a pitched roof formed of slates and sarking supported by steel roof trusses. In the design of the piers and panels, economical and structural requirements as well as the architecture of concrete work were kept in view. Gate pillars, dwarf walls, road foundations, are all of reinforced concrete.

The stripping of steel and wooden shuttering and centering has been carried out in accordance with the possibilities of rapid-hardening Portland cement recommendations, with the result that very rapid progress is being maintained. One or two spells of hard frost were encountered, but by heating the sand, aggregate, and water by means of a vertical boiler and steam tubing the pouring of concrete was carried on without interruption.

The dairy will use a large quantity of water for cooling and other industrial purposes. A 50,000-gallon reinforced concrete circular tank, about 85 ft. high, will be erected with two concentric compartments; the outer compartment, of 43,000 gallons capacity, will hold the primary water, and the inner compartment, of 7,000 gallons capacity, will hold the secondary water, which will be pumped from a 50,000-gallon collecting tank under the floor of one of the loading docks.

It is expected that the concrete work will be completed in the next few months.

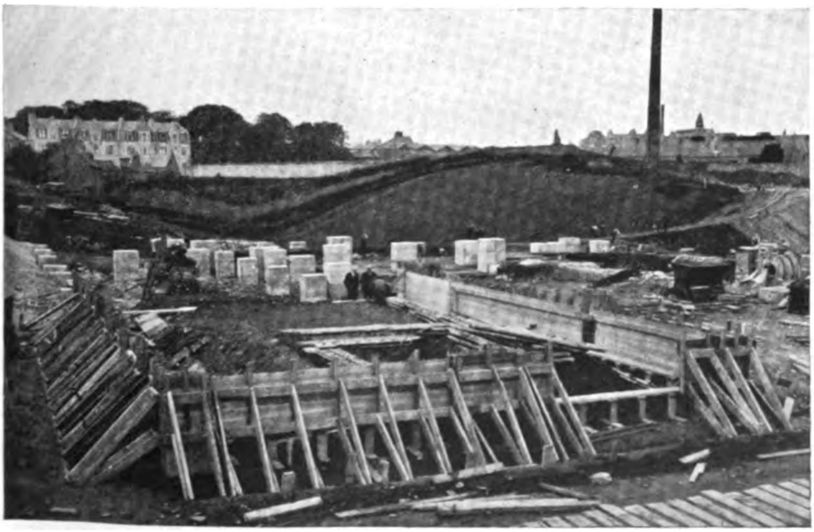


Fig. 1.—First Lift of Shuttering in Three Walls.

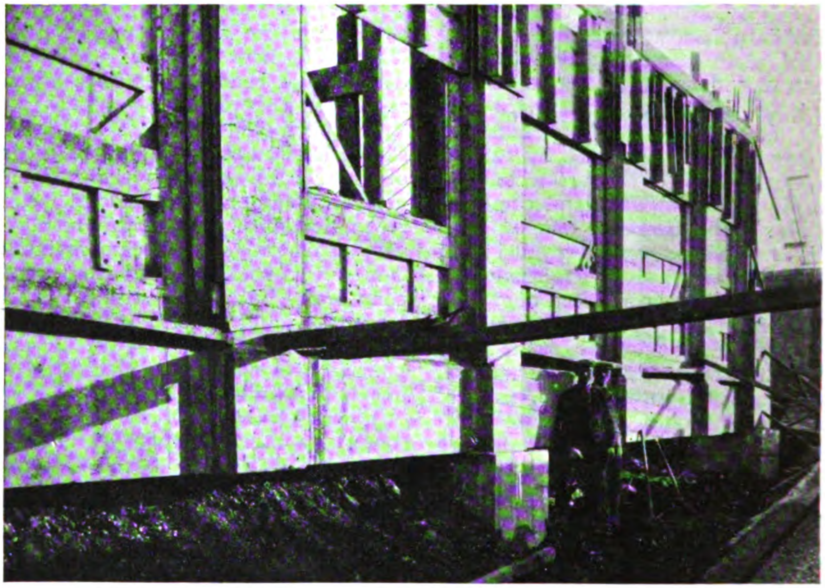


Fig. 2.—Junction of Superstructure and the Pier Foundation.

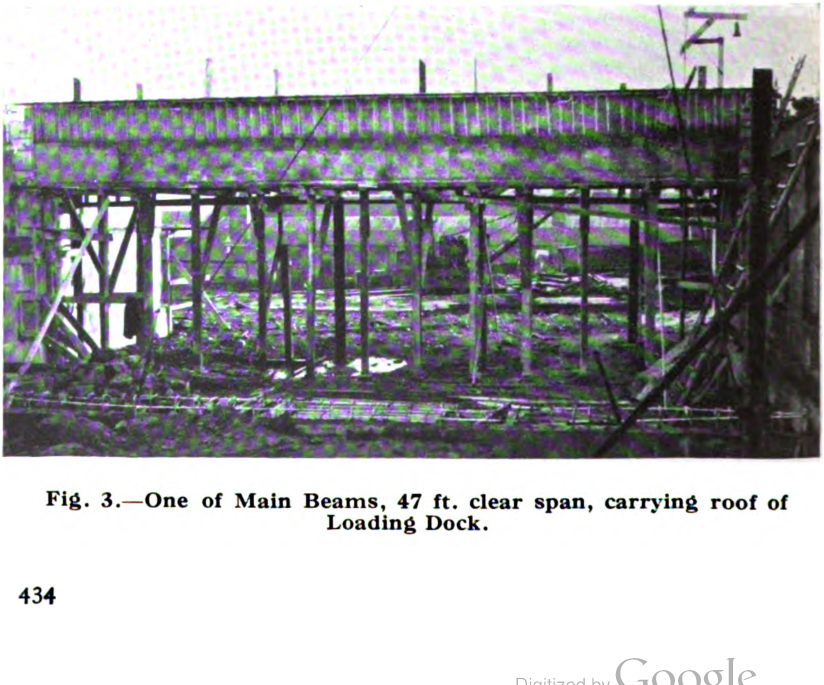


Fig. 3.—One of Main Beams, 47 ft. clear span, carrying roof of Loading Dock.

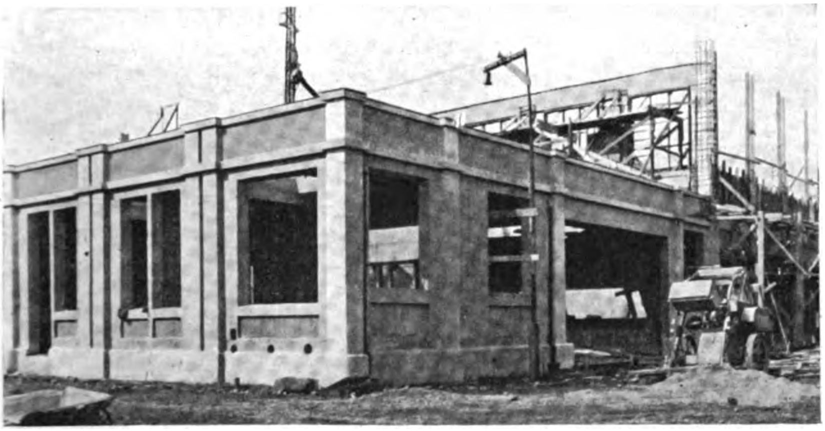


Fig. 4.—South-East Corner : A surface treatment scheme is adopted for the pilasters, pillars, panels, etc., including rubbed surfaces and white Portland cement.

The architects and engineers are Messrs. Tawse & Allan, of Aberdeen.

The illustrations show: *Fig.* 1, the first lift of concrete in three walls (the hill in the background is being removed and used for banking over the site); *Fig.* 2, the junction of the superstructure and pier foundations; *Fig.* 3, one of the main beams carrying the roof of a loading dock (the span is 47 ft. clear, the top of the fill is approximately the level of the roof); *Fig.* 4, view of the south-east corner (the surfaces of the base-course, pillars, pilasters and belt-course will be rubbed down with carborundum, and the panelling finished in white Portland cement; the sunk panels will have the aggregate exposed.)

The Addition of Lime to Concrete.

In the course of some notes on the construction of an elevated roadway in reinforced concrete at Chicago, Mr. A. R. Lord, the consulting engineer on the work, refers to the admixture of lime to the concrete in order to facilitate its deposition. This is one of the large reinforced concrete works completed in Chicago in recent years, and involved an exceptionally large volume of concrete, all of which was used as "dry" as possible with a view to securing maximum strength.

The addition of lime was specified for reinforced concrete other than lightly reinforced massive work and except in cold weather. The engineer states: "Lime was not used from any faith in reported test data, where an increase in strength due to other causes has been attributed to lime, but for practical reasons. We found that the use of 50 lbs. of hydrated lime per yard batch of concrete had no observable effect on the strength of the concrete; and we have probably three thousand tests to judge from. We found also that the use of lime in this proportion made the concrete more workable, easier to place, and less liable to segregation in transportation and handling. Past experience indicated that it decreases permeability, while twenty years' experience in its use in this manner has not confirmed any opinions to the effect that the lime will be carried away after the concrete is once properly made and placed."

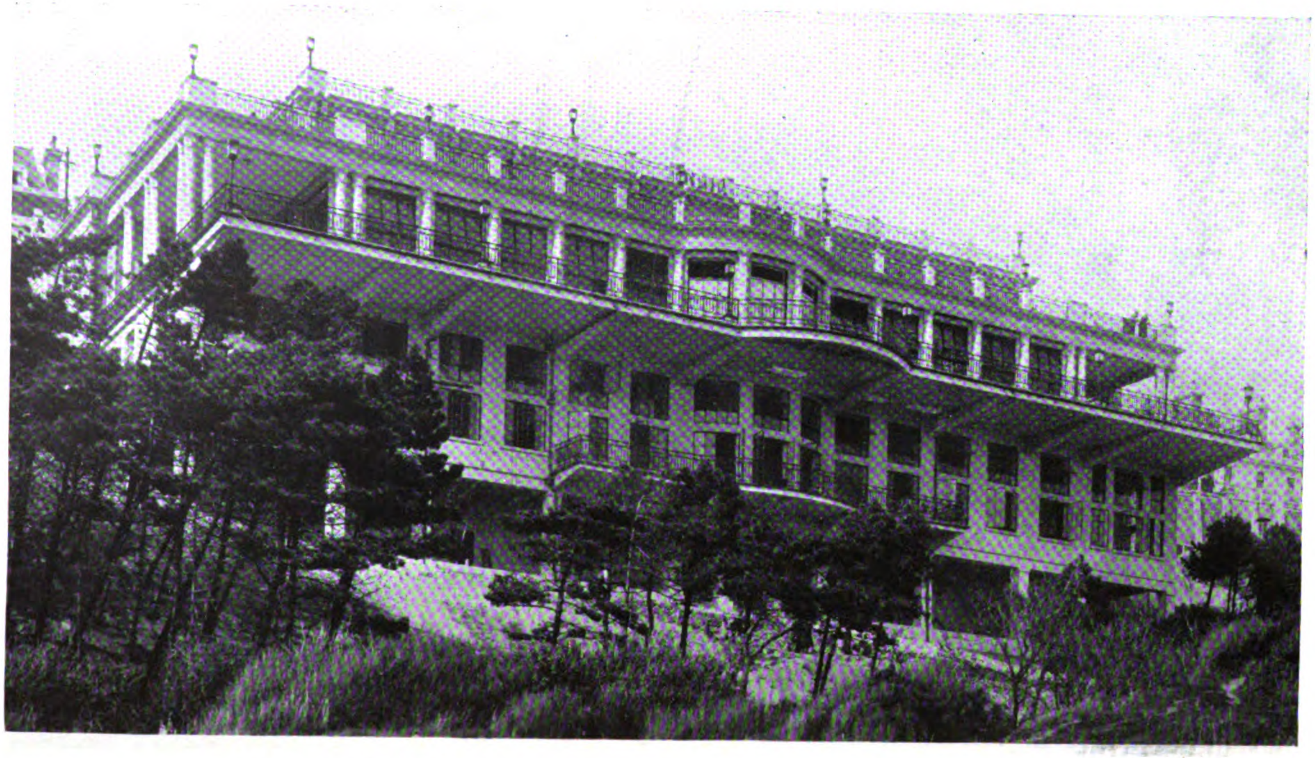


Fig. 1.—Leas Cliff Hall, Folkestone: Front View. (*See p.* 437.)

Leas Cliff Hall, Folkestone.

THIS recent and important addition to the already numerous amenities of Folkestone is constructed on the Leas, and comprises, as well as a large concert hall and band pavilion, a promenade, balconies, shelters, tea rooms, and other conveniences. The structural material is almost wholly reinforced concrete, the consulting engineers for which were Messrs. Considère Constructions, Ltd., of Westminster, S.W.1.

The external facing material is white faience work, and the architectural treatment it has received is very suitable indeed to its position and environment. This may be seen from *Figs.* 1 and 2, which give external views of the work. The principal idea in designing this work was to have as many balconies as possible, so that the public could hear music, and at the same time be out of doors and enjoy unrivalled views of the English Channel, shipping, French coast, etc.

The two balconies on east and west sides are covered for wet weather and the main hall windows open entirely so that the hall can be thrown completely open. The external windows are of metal, and these have been treated with a zinc spray finish to prevent rusting, which is an important question at seaside places.

The main hall, which has accommodation for 1,500 people, is provided with a dance floor. Synchronising clocks have been fitted throughout, and telephone communication is installed between the various rooms.

Large subscription rooms for reading, writing, etc., together with a silence room, are provided on the middle floor, while on the mezzanine floor are retiring rooms for artists, bandsmen, etc. The central heating is low pressure with oil-fired boilers. Heavy crude oil is employed and this is pumped down from the road above.

The principal feature structurally is the main cantilevered balcony, with a clear projection of 17 ft., which extends the whole length of the building. Beneath this is a smaller balcony which traverses a portion of the façade.

Fig. 3 shows a typical transverse section through the building. This illustration shows clearly the constructional arrangements and the cantilevered balconies referred to.

The site chosen for this building, whilst almost perfect from the æsthetic and accommodation standpoints, required careful investigation and consideration in order to provide efficient foundations. The slope upon which the majority of the structure stands is relatively steep, and the height of the shelter (shown in the cross section) is about 80 ft. above the foreshore below.

It was obviously desirable, so far as possible, to keep the dead weight of the front portion of the structure as small as possible. Several means were adopted to this end, one being the use of hollow or trough flooring of reinforced concrete for the main balcony and adjacent pavilion. These floors, although spanning about 20 ft. between beams, were of minimum dead weight, and possess excellent sound-resisting qualities. The underside of the floors were provided in all cases with plaster ceilings formed on expanded metal, the latter being attached to the rib soffits in the usual manner.

The building has taken two years to complete, and the cost, including furniture, amounts to about £80,000. The opening ceremony is to be performed by H.R.H. Prince Henry on July 13. The architect for the work is Mr. John Seaton Dahl, F.R.I.B.A., and the general contractors Messrs. Godden & Son, of Ashford, Kent.

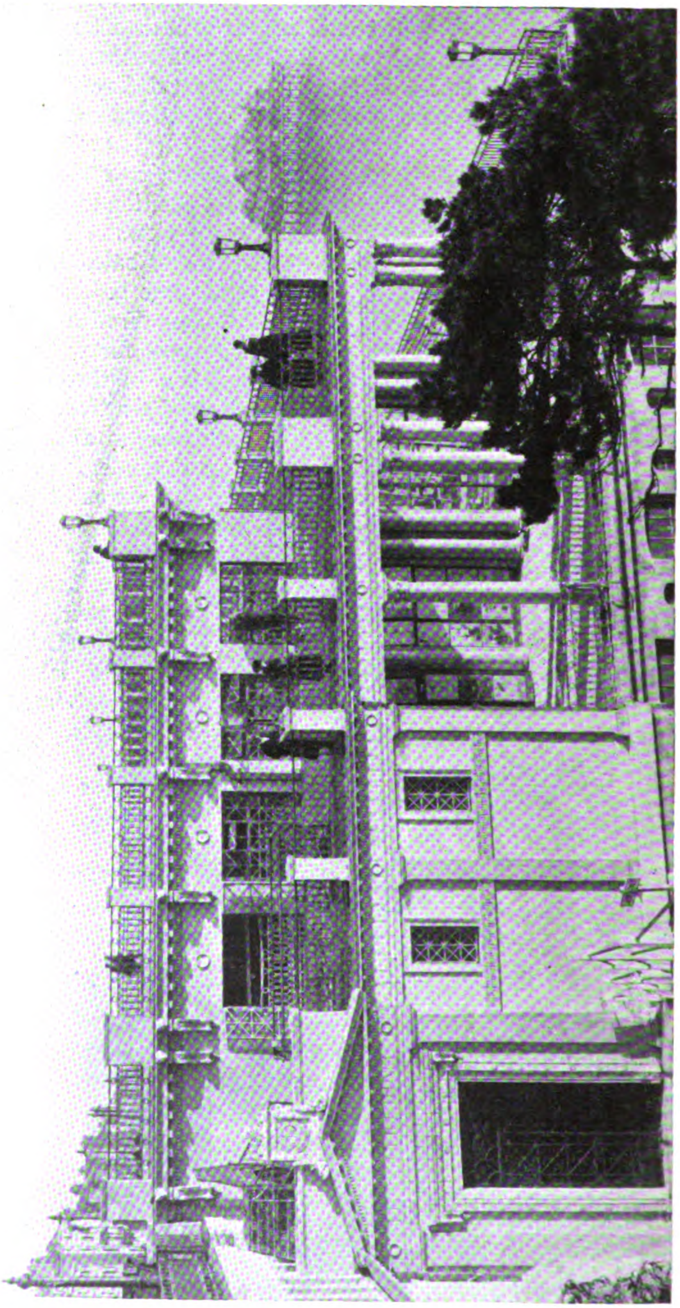


Fig. 2.—Leas Cliff Hall, Folkestone: End View. (*See p.* 437.)

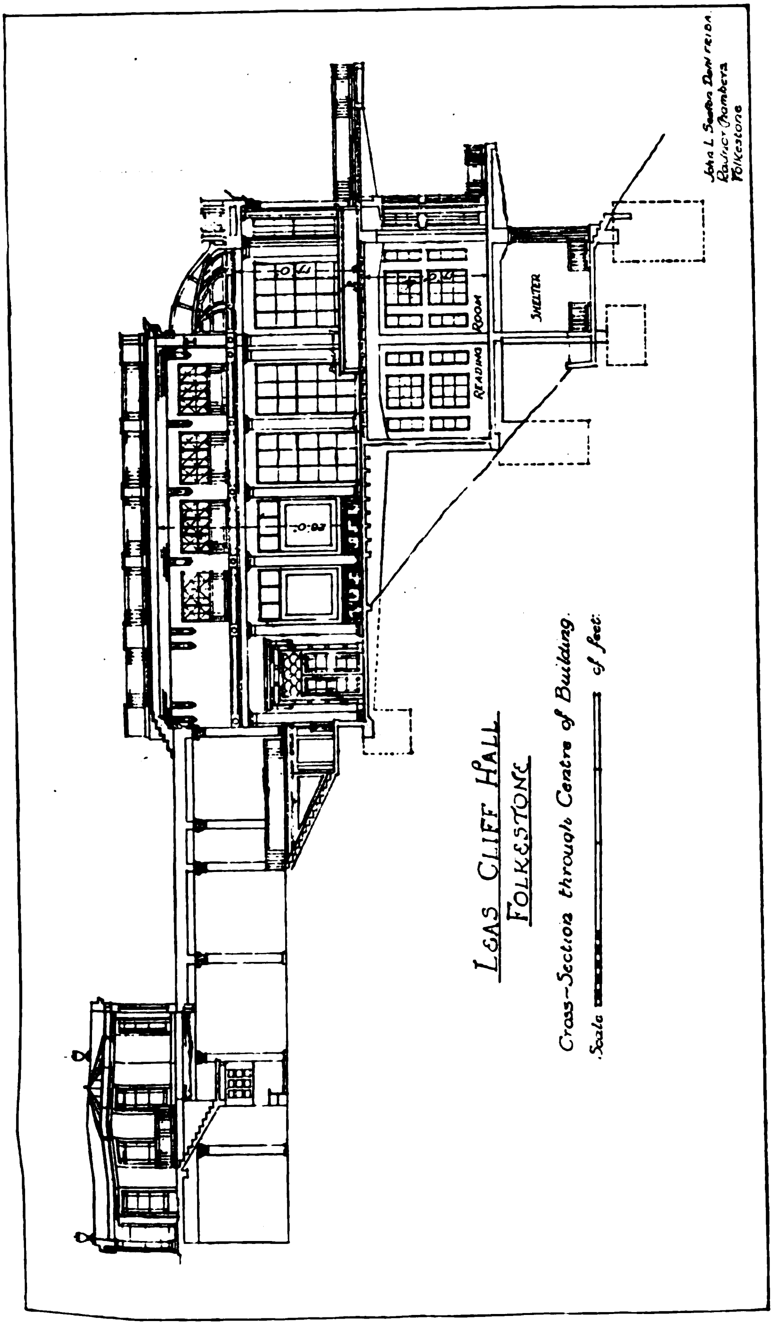


Fig. 3.—Leas Cliff Hall, Folkestone: Cross Section. (*See p.* 437.)

Questions and Answers relating to Reinforced Concrete.

Readers are cordially invited to send in questions relating to concrete. These questions will be replied to by an expert, and, as far as possible, answered at once direct and subsequently published where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—ED.

Casing Rolled Steel Joists.

QUESTION.—I would be obliged if you would give your advice on the following question. In a bridge 28 ft. span by 12 ft. wide, rolled steel joists 16 in. by 6 in. by 62 lbs. per foot run at 3 ft. centre to centre, are to be filled in with 5 to 1 concrete on curved sheeting as sketch No. 1, or altered and constructed as sketch No. 2, with 4 in. of concrete above and below the joists. (1) Can the formula for concrete above top flange of joist in Redpath Brown's Handbook be used with large rolled steel joists of this span and upwards, say, to 30 ft. span? (2) What is the advantage of No. 2 over No. 1? (3) What is the best way of constructing the bridge as regards concrete filling?—T. PRICE, Brecon.

ANSWER.—(1) The formula quoted by our correspondent cannot be used for the size of joist mentioned, as the percentage increases in strength due to the surrounding concrete are not tabulated for joists larger than 10 in. by 5 in. by 30 lbs.

(2) There will be a slight increase of strength in Sketch 2 over Sketch 1 owing to the presence of the concrete above the top flanges of the joists. The concrete below the lower flange, however, is of no value except as a casing and protection to the joist. Apart from the latter consideration, therefore, there appears to be no advantage in Sketch No. 2 over Sketch No. 1. Indeed, the extra 8 in. or 9 in. of concrete in Sketch No. 2 adds another 100 lbs. per sq. ft. to the 240 lbs. per sq. ft. deadweight of Sketch No. 1, resulting in a total deadload of about 13 tons per joist, thus leaving little margin for the carrying of useful live load.

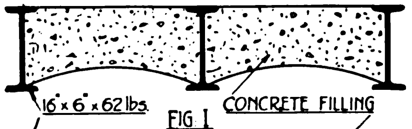


FIG I.

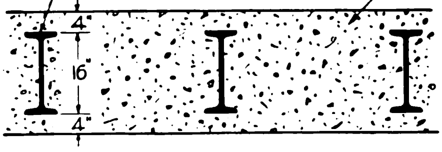


FIG II.

(3) In the case of Sketch No. 2, the formwork must be supported on props from below as a floor, unless special metal clips or bolts are made to hook over the flange of the rolled steel joists to support the timber joists carrying the boarding.

Stresses in Reinforced Concrete.

QUESTION.—In the May number of "Concrete and Constructional Engineering" I find it difficult to understand your remark on page 333, "it is inconsistent with the usual basis of design . . . etc."

Surely it is the very essence of design in reinforced concrete that the stresses in steel and concrete are relative to their modulus of elasticity, and that if the stress in steel is 16,000 lbs. per square inch the corresponding stress in the concrete adjacent is $\frac{1}{15}$ of that figure, viz. 1065. If the concrete cannot stand this stress it will crack, leaving all the tension to be taken by steel. Is this not the basic theory of reinforced concrete construction?

I should be obliged if you would explain what is meant by your remarks on Mr. W. T. Gedge's diagrams.—W. H. CHAMBERLAIN, Belfast.

ANSWER.—Our correspondent's statements seem to be perfectly correct, and his views, so far as we can see, are fully in accordance with the views expressed in the editorial. The only point is, of course, that whereas our correspondent recognises that if concrete in tension cannot stand a stress of 1065 lbs. it will crack, leaving all the tension to be taken by the steel, this point did not seem to be borne out by Mr. Gedge's diagrams, which still showed stresses of 1065 lbs. and other impossibly high stresses in concrete in tension below the neutral axis which could not possibly exist.—O.F.

Concrete Roads: Faults and their Lessons.—II.

By R. A. B. SMITH, A.M.Inst.C.E., A.C.G.I.

(Continued from "C. & C.E.," June, 1927.)

WHEN the joints are straight across the road the longitudinal crack generally appears fairly continuously through three or four panels; it may then fade away in one or more panels, only to reappear in the following ones. This type of crack has made its appearance more quickly on made-up ground than on a natural sub-base, which leads one to suspect that there is additional vibration due to heavy loads over made ground in consequence of which the tension at the centre is increased at the moments when these loads are passing, especially during the heat of the day, at which time the centre portion may be hollow.

If the joints are placed diagonally across the road the cracks appear as shown in the photograph with the previous article or else run at right angles to the joints through two or three bays, eventually reaching the edge of the slab.

It is not yet evident that the placing of top reinforcement in one direction or the other makes any difference; that is, these cracks do not seem to be prevented whether the top reinforcement runs parallel to or at right angles to the joints, or even if the bars are spaced equally in both directions. Hence it may be assumed that to avoid this type of crack either the concrete at the centre of the road must be thickened or additional top reinforcement must be placed in the middle third.

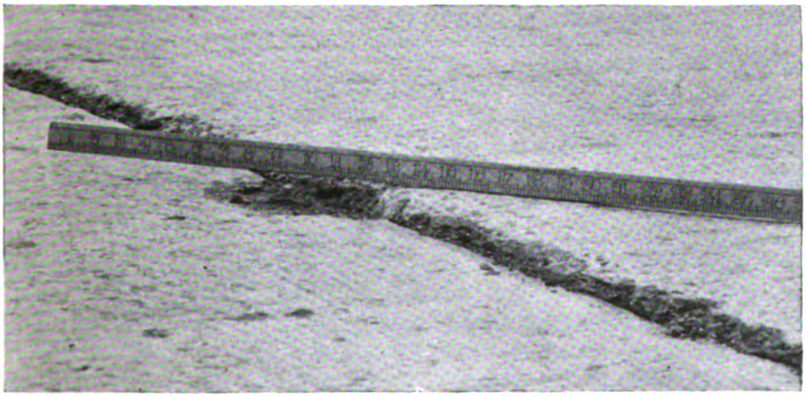


FIG. 1.—OVERRIDING OF JOINT BETWEEN LONG SLABS.

The thickening of the centre has been done at the following places :—

Manchester : 12 in. at centre, 9 in. at sides.

St. Austell : 8 in. at centre, 7 in. at sides, and 7 in. at centre, 6 in. at sides.

Surrey Commercial Docks : 10 in. at centre, 8 in. at sides, and 11 in. at centre, 7 in. at sides.

Bourne End : 8 in. at centre, 6 in. at sides.

Gainsborough : 9 in. at centre, 6 in. at sides.

An example of extra reinforcement in the midde third is in the East to West Road at Dorking, Surrey. There are more which might be mentioned, but the above should be sufficient for those interested to keep in touch with over a period of time.

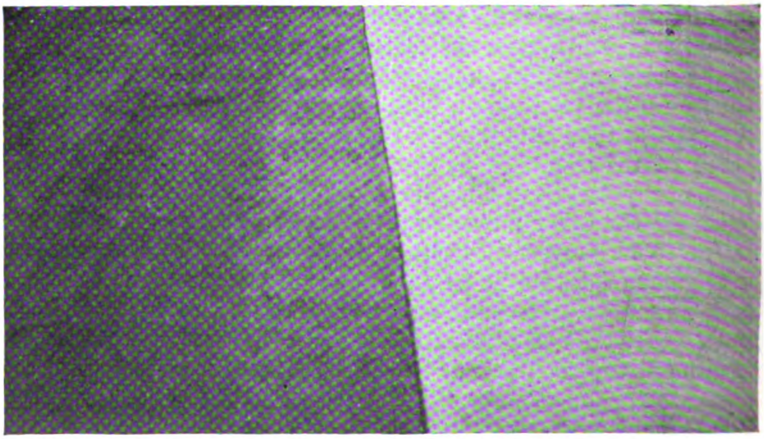


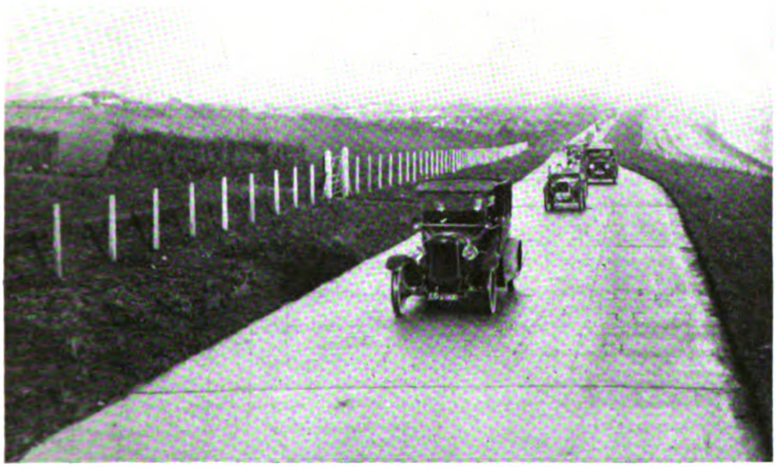
Fig. 2.—Road Laid in Half-Widths.

It was about the year 1919 that one or two engineers adopted a third method of constructing slabs for concrete roads. In this method the slab was laid the full width of the road, and the concreting was continuous right through until the end of the day's work, when a plain vertical butt joint was used. The reinforcement did not pass through this joint. The next day's work was then continued straight off from the butt joint.

So far as Southwark is concerned this method has been quite successful. It does not entirely eliminate cracks, but it is a simpler method of construction than the alternate bay work and is less costly.

It was found, however, that the use of a joint only at the end of a day's work meant that when progress was good the length of the bay was sometimes anything from 150 to 200 feet. Under temperature effects the expansion of this length of concrete was so great that, if the joint were not absolutely true, one slab would often try to over-ride the next (*Fig.* 1); and, even if the butt joint were quite true, there was a tendency for the slab to lift in the middle, with the result that a hollow was formed underneath and cracking inevitably took place due to the traffic passing over this portion. The writer has observed most distinct differences of level between one slab and another as a result of expansion when there is a considerable distance between the joints, although on previous examinations there had been no appreciable over-riding.

A considerable amount of slab work has been done both with and without expansion joint material, and it now seems definitely proved that it is inadvisable to exceed 70 ft. at the outside, and preferably to keep within 60 ft., as the maximum length of the slab. Such a slab will last a considerable period without developing anything in the nature of cracks, but eventually the longitudinal crack does appear. This type of crack is zig-zag in shape, and sometimes deviates and finishes at the edge of the slab. It is, therefore, difficult to treat in order to prevent disintegration when it has opened sufficiently for the traffic to have effect upon the edges.



Mr. W. C. Persey, Borough Engineer.

FIG. 3.—ROAD AT BARROW-IN-FURNESS WITH EXPANSION JOINTS AT VARYING INTERVALS.

There is a road at Barrow-in-Furness, 3½ miles long, which was opened to traffic in June, 1924, and in which the majority of the bays do not exceed 60 ft. in length. The width of the road is 24 ft. With those bays that are 60 ft. in length it is true there are a few cracks, but it has not so far been necessary to treat them. With the bays that vary in length from 90 to 100 ft., of which there are very few, there is, however, a distinct heaving at the joints. As the whole of the road was constructed under exactly the same conditions and in exactly the same way it is an interesting example, and a very good argument in favour of restricting the length of the panel to the dimension mentioned (*Fig.* 3).

Although there were early instances of roads being constructed in two halves the object of this was to allow the traffic to pass during the reconstruction of the road. Nevertheless it became noticeable that the centre joint thus formed, even though the utmost care had been taken to join up the two sections on completion, both with top reinforcement and by taking particular care in the bonding of the concrete, after a period opened and if not treated with a bituminous preparation would commence to ravel (*Fig.* 4). However, the joint being a straight line it is not difficult to treat. On the other hand, the reduced size of the panel seemed to be of an advantage inasmuch as the total length of crack per panel was appreciably reduced.

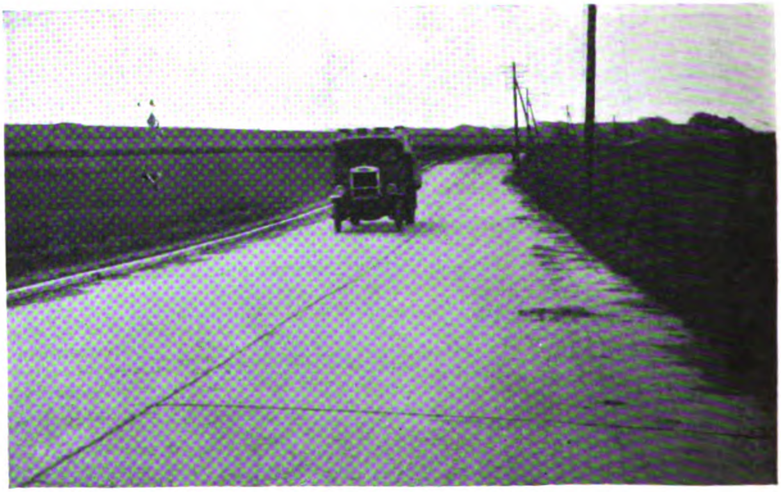
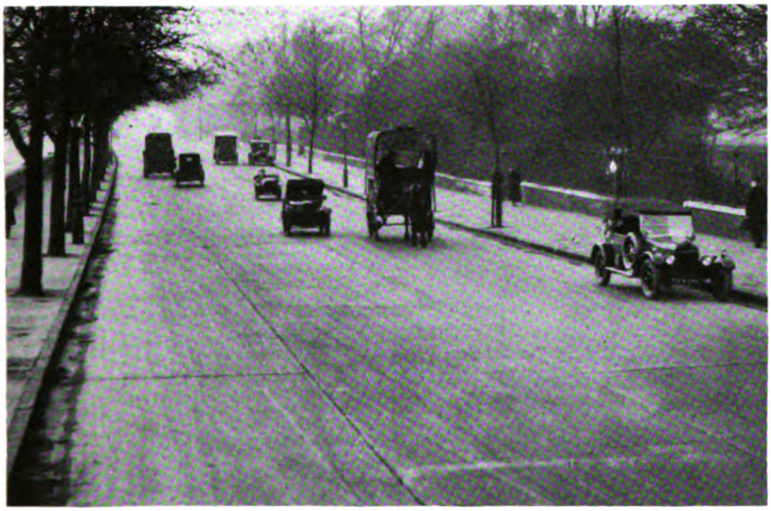


FIG. 4.—OPENING OF CENTRE JOINT IN HALF-WIDTH CONSTRUCTION.

In the spring of 1926 it was decided to construct a road on the Chelsea Embankment, London, where the traffic is both heavy and rapid. It was essential, therefore, that if a concrete road were constructed, it should be capable of withstanding the hardest test of all, namely, speed and weight together. It was thought that if longitudinal cracks were allowed to form in this road they would require constant attention. The engineer therefore in designing the road, divided it up into three strips roughly 13 ft. wide, and kept the panels down to 50 ft. in length. However, when it came to the actual construction, in view of the fact that the Ministry of Transport required the road to be kept open to a double line of traffic it was not found practicable to lay the road in three strips. It was decided, therefore, that four strips each 10 ft. wide should be adopted (*Fig.* 5). During the course of these articles several references will be made to this road, as many interesting details were adopted and one or two interesting points have since arisen.

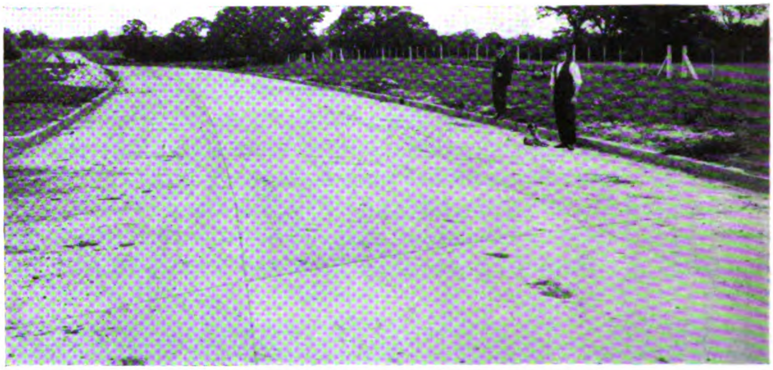


Mr. W. R. Manning, Borough Engineer.

FIG. 5.—ROAD LAID IN FOUR STRIPS ON CHELSEA EMBANKMENT.

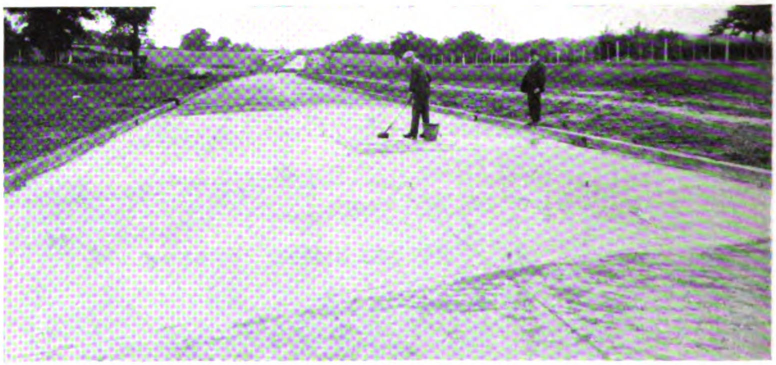
It may, however, be stated that as a result of investigation after a period of one year, the size of the slab (48 ft. 4 in. by 10 ft.) has proved satisfactory inasmuch as there is in the whole area only one corner break and some very minor cracks.

During the summer of the same year the Ministry of Transport, in conjunction with the Middlesex County Council, constructed several test sections of concrete-surface roads on the Barnet By-pass. The majority of the panels are 30 ft. long, and the width of the road is also 30 ft. Some of the sections are therefore 30 ft. by 30 ft.; a second series is 30 ft. by 15 ft., that is to say, the road has been divided into halves;



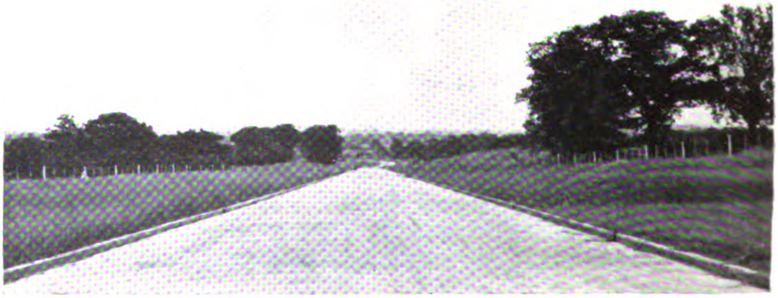
Mr. A. Dryland, Middlesex County Surveyor.

FIG. 6.—SECTION OF BARNET BY-PASS ROAD LAID IN THREE STRIPS.



Mr. A. Dryland, Middlesex County Surveyor.

FIG. 7.—SECTION OF BARNET BY-PASS ROAD LAID IN TWO STRIPS.



Mr. A. Dryland, Middlesex County Surveyor.

FIG. 8.—FULL-WIDTH CONSTRUCTION ON BARNET BY-PASS ROAD.

and a third series is 30 ft. by 10 ft., the road having been divided into three strips (*Figs*. 6, 7, and 8).

Very little traffic has so far used the road, and it may therefore be assumed that anything that has happened to the road is due to temperature effects. One or two longitudinal cracks have occurred in the 30 ft. by 30 ft. panels, but so far as the writer is aware no cracks have yet developed in any of the others. The majority of the sections are unreinforced; the thickness of the slab is 8 in.

All the various forms of construction which affect the size of the panel have now been considered, and the next step is to diagnose the advantages and disadvantages of each and endeavour to arrive at a decision at what is likely to prove the correct size of panel. The question of joints and jointing materials will be dealt with later.

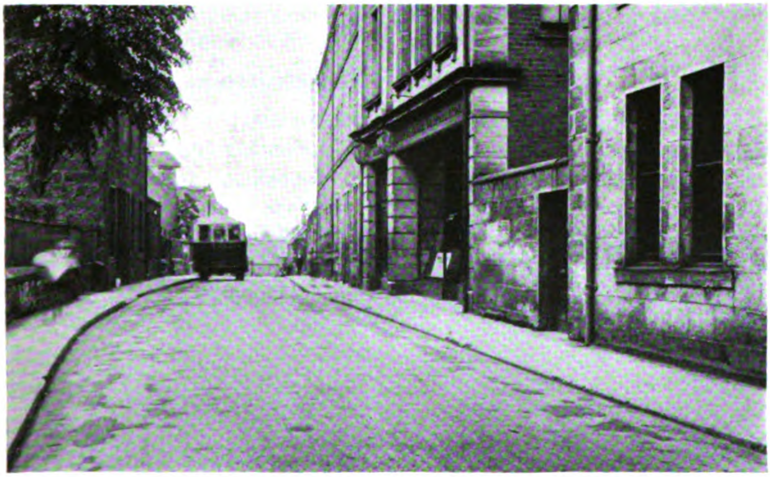
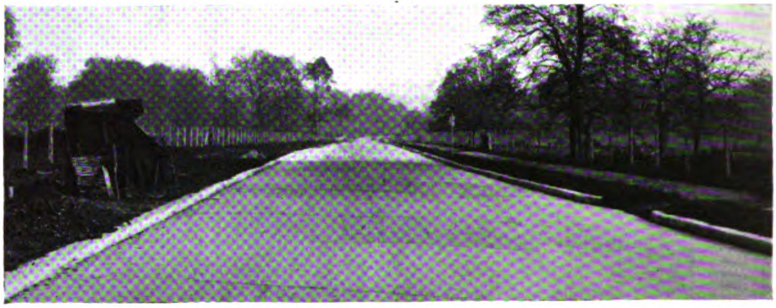


Fig 9.—Continuous Construction at Dunfermline.

Continuous Construction.

The advantages of continuous construction (*Fig*. 9) are simplicity of construction for streets up to 24 ft. in width, and the fact that in very well-protected areas it does not seem to develop cracks for a considerable period.

Its disadvantages are that zig-zag cracks occur where this form of construction is employed on streets that are at all exposed; construction joints are liable to open; and bursts are a possibility.



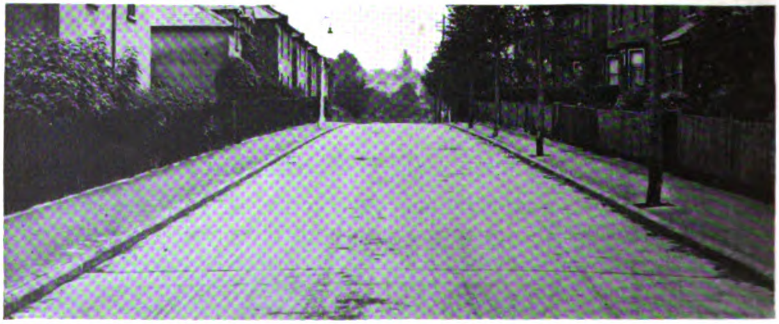
Mr. W. P. Robinson, Surrey County Surveyor.

FIG. 10.—ALTERNATE BAY CONSTRUCTION ON EAST TO WEST ROAD, REIGATE.

Alternate-Bay Construction.

The advantages of alternate-bay construction (*Fig.* 10) are that it can be used on roads up to 60 ft. in width; the camber can be accurately kept over such a width; mixing in a clean condition can be accomplished on the alternate bays whilst the intermediate bays are being laid; and, provided that the screeding is strictly longitudinal, smooth riding can be obtained.

Its disadvantages are that the whole road must be closed to traffic until its absolute completion; the method is more expensive; extra reinforcement or extra depth of concrete is necessary to reduce the possibility of a centre crack. The slabs should be not less than 10 ft. wide to prevent tilting, and a special watch must be kept that the full depth of concrete is laid in the intermediate bays.



Mr. W. H. Grieves, Engineer and Surveyor, Sutton U.D.C.

FIG. 11.—BUSHEY ROAD, SUTTON, LAID IN FULL WIDTHS WITH EXPANSION JOINTS.

Expansion-Joint Method.

The advantages of this method are simplicity of construction and reduced transverse cracking (*Fig.* 11).

The disadvantages are the formation of longitudinal crack, and also the whole road has to be closed to traffic during construction.

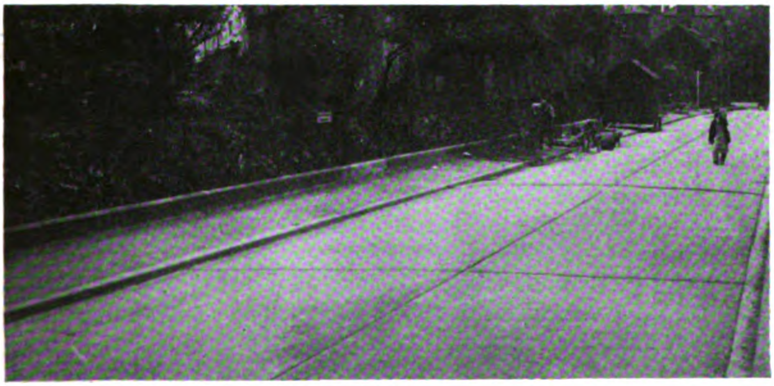
(*To be continued.*)

Strip Method.

The advantages of this method (*Fig.* 12) are simplicity of construction; screeding is simplified due to narrow width; more accurate alignment and level is possible, ensuring smooth riding qualities; longitudinal and transverse cracks are practically entirely eradicated; the road can be open to traffic throughout the construction period; there is complete freedom from heaving or bursts.

The disadvantage is the number of joints, necessitating an annual treatment and considerable care during construction.

It may be deducted, therefore, that in the writer's opinion it is preferable to lay slabs longitudinally of a length not exceeding 60 ft. when reinforced, and 30 ft. when unreinforced. The thickness must be not less than 6 in., and need not exceed 9 in. When long life is not desired, and should a case arise where funds do not permit of permanent work, it is a reasonable proposition to put down a layer of concrete 4 in. to 5 in. thick on a good foundation and obtain a longer life with this than with any other material of a similar cost per square yard, but it cannot be considered a permanent form of paving.



Mr. J. S. Bullough, Borough Surveyor.

FIG. 12.—ROAD AT NORWICH LAID IN STRIPS.

Low Retaining Walls.

By LESLIE TURNER, B.Sc., A.M.Inst.C.E.

THESE notes refer to the construction of comparatively shallow retaining walls up to about 6 ft. total height, and of any length, such as would be suitable for supporting a bank of earth up to, say, 4 ft. 6 in. high.

Let us assume that the net height of ground to be supported is 4 ft. 6 in., that is, from lower ground line (L.G.L.) to higher ground line (H.G.L.) (see *Fig.* 1). Any wall of lesser net height can be constructed from the following particulars by deducting the difference from the top; that is to say, by lowering the coping but retaining the same base, reinforcement, and other dimensions as shown.

This type is termed a cantilever wall in contradistinction to a counterfort or buttress wall, and it has been designed to retain ordinary earth trimmed to an approximately level upper surface on which only light loads (if any) would occur. If the backing is likely to be waterlogged, or to carry heavy loads—such as from a roadway, a railway, or a raft for a building, etc.—this design would not apply and specialist advice should be sought.

For the moment it will also be assumed that H.G.L. and L.G.L. are horizontal or are to be finished so, as sloping sites necessitate modifications.

Excavation.

Excavation must be carried down to the depth 1 ft. 9 in. shown on the section, and this should be considered a minimum for ordinary ground. If a good natural bearing is not found at that depth the excavation should be continued deeper until a satisfactory stratum is reached and then filled up with mass concrete (1 : 2½ : 5 mix) to the level of the underside of the base slab.

On the other hand, even if very good bearing ground is exposed before the above-mentioned depth is reached, excavation must proceed to the full depth because it is required to form a buffer to resist the thrust on the back and thus to prevent forward movement of the wall. It is therefore essential that the space marked A on *Fig.* 1 be refilled with good material and well consolidated after the wall is built. The only case permitting a reduction of excavated depth in front of the wall would be when the toe (T) thrust directly against an extensive concrete slab or rock, etc.

Except in very compact ground it is desirable to run some rough boarding along the sides of the trench to prevent soil or the sides falling in before or during concreting.

For shallow banks it will perhaps be found cheaper to trim the bank back to a slope at which it will stand safely without danger of downwash by heavy rains. If, however, this is not possible owing to lack of space for spoil on top or other causes, and in the case of greater height, the face of the bank must be roughly but adequately timbered and strutted as shown dotted in *Fig.* 3, to retain temporarily the bank and prevent earth falling down into the trench.

Rough boards will then be required with posts wired back to stakes or strutted in front, as the circumstances permit. This is a matter of trench strutting, and will not be pursued here except to point out that any struts should if possible be kept clear of the future wall and its shuttering. It is worth while thinking this out clearly, otherwise the special cutting to enable temporary struts and props to run through the wall will add seriously to the cost of the job, and will afterwards be a source of weakness and trouble.

We will now assume the preceding operations are finished, and that we have a clean and firm bottom to receive the base.

During wet weather it may be difficult to keep the bottom free from

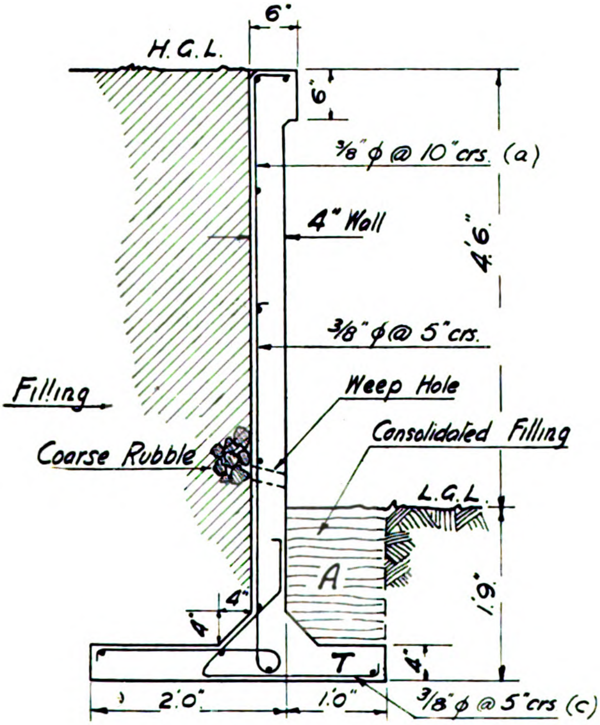


Fig. 1.—Section EF on Fig. 2.

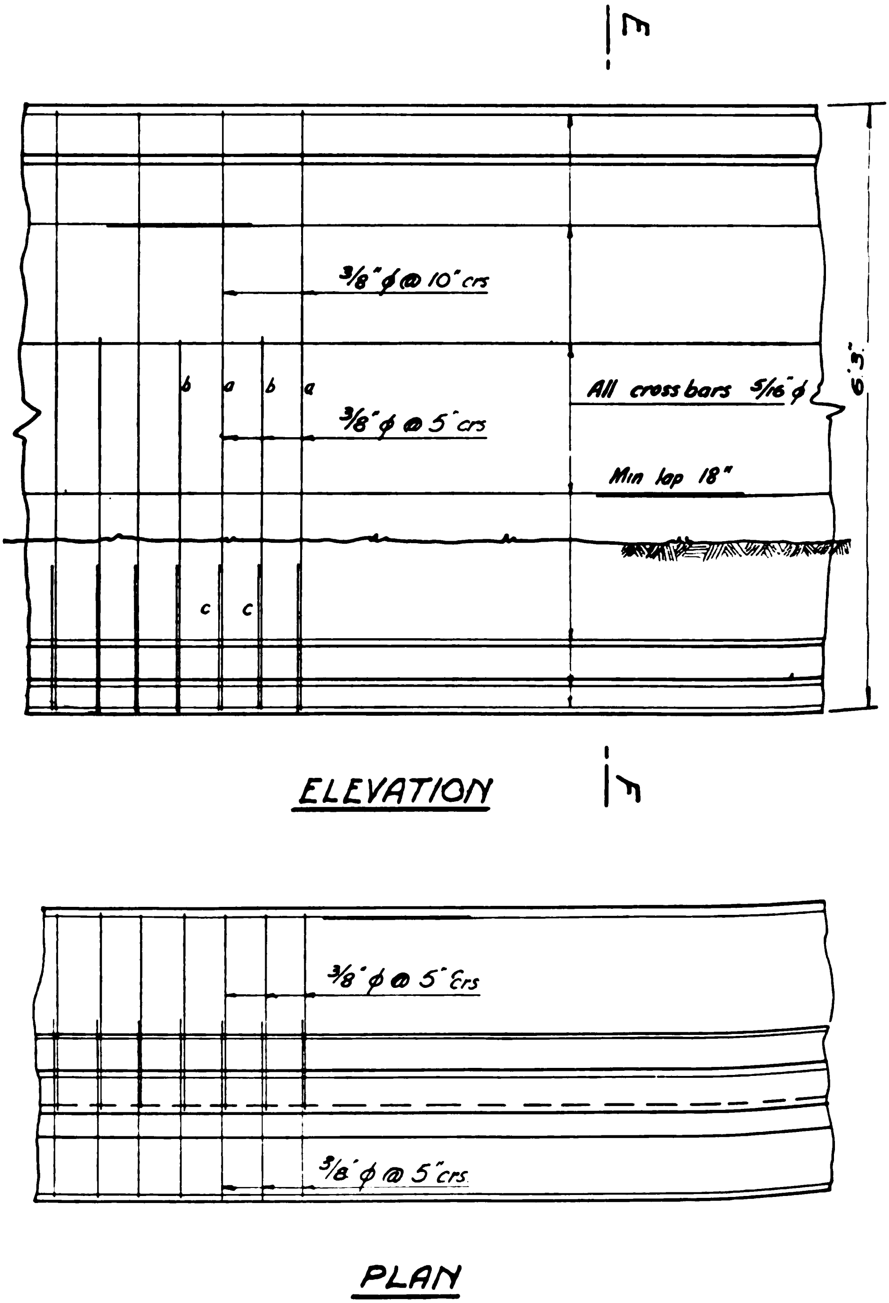

E
3/8" φ @ 10" crs
b a b a
3/8" φ @ 5" crs
All cross bars 5/16" φ
Min lap 18"
6' 3"
c c
ELEVATION
E
3/8" φ @ 5" crs
3/8" φ @ 5" crs
PLAN

Fig. 2.

mud, which must on no account be allowed to become mixed with the concrete or to coat the bars. In this case and in wet ground, therefore, a layer of rough concrete 1½ in. to 2 in. thick should be given to the bottom of the trench to form a level and hard working floor. This concrete is, of course, additional to the 4-in. reinforced concrete base, and the excavation must also be carried 2 in. deeper to accommodate it. Any reinforcement (dealt with later) occurring in or projecting into the base-slab must now be placed, wired tightly together at all crossings with short lengths of annealed iron wire (No. 16 gauge) and securely held in position by a temporary wooden frame, or any means that suggests itself.

The main bars (i.e. all but the crossbars) are to have ½ in. cover of concrete. This can be conveniently achieved by placing short loose lengths of ½ in. diameter bar between the reinforcement and the ground or the shuttering. These form gauges, and can be moved along as concreting proceeds ; but it is necessary to move them along before ramming is finished, or continuous holes will be left on the surface of the concrete. Wood blocks or strips should not be used, for if accidentally concreted in they may seriously affect the strength of the structure. A short study of the plan, elevation, and section in *Figs.* 1 and 2 will show that the ⅜-in. bars forming the vertical reinforcement must be inserted together with the four $\frac{5}{16}$ in. crossbars in the base.

The base slab may now be concreted to its full depth of 4 in. in one operation. This should be carried out in convenient short lengths, terminated by removable staked boards against which the concrete can be rammed. Care must be taken during the punning to ensure that the concrete is rammed between and under the bars without displacing them.

Shuttering.

A simple and satisfactory method of shuttering is shown in *Fig.* 3, the essential parts being posts, say, 4 in. by 3 in., at about 3 ft. intervals supporting horizontal 1¼-in. boards or sheeting. The posts must be braced longitudinally, and also strutted at front or rear when in position and plumb. With 1¼-in. boards the pairs of posts would be separated 6½ in. to give a 4-in. wall. The posts and sheeting must be cut to form 4 in. by 4 in. fillets, 6 in. by 2 in. coping, and the smaller 1 in. by 1 in. fillets. For a long stretch of wall one or two unit lengths of standardised shuttering should be made, which can be dismantled and reassembled.

The posts may be strutted from other timbering at the bottom, or bolted or wired through the shuttering to the opposite post. Such bolts or wires should if possible be withdrawn and in any case kept well below front ground level. At their tops the posts are connected by a nailed strip.

One side of the sheeting can be erected to the full height of the wall, but an open side must be left above the 4 in. by 4 in. fillets so that the concrete can be poured, crossbars wired on, the concrete rodded, and the whole easily inspected. Concreting should be carried up in 12-in. layers, by inserting two or three boards at a time on the open face and filling up, the ends of a section being stopped with removable boards to ram against.

At about 6 in. or 9 in. above L.G.L. tapered cylindrical blocks of wood should be cast in, and these can be knocked out later to form weep holes at 10 to 15 ft. centres.

The top surface of the coping need not be shuttered, but the concrete brought up flush and trowelled off smooth.

Reinforcement.

Reinforcement should consist of round bars of the diameters indicated in *Figs.* 1 and 2. The 8 ft. 11 in. long ⅜ in. bars (*a*) at 10 in.

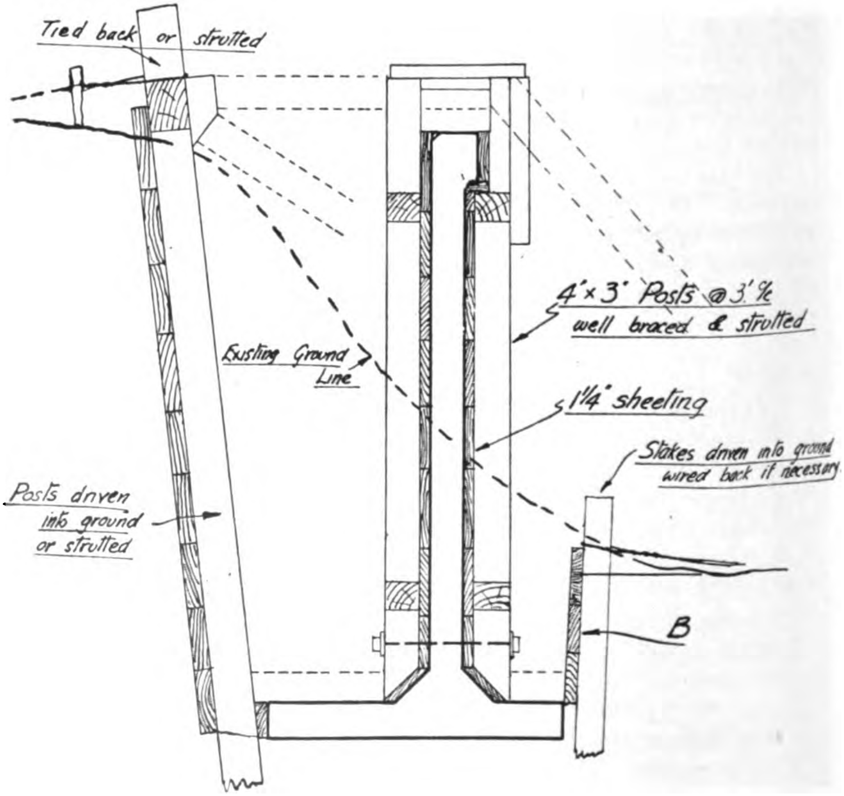


Fig. 3.

centres alternate with the 6 ft. 4 in. long ⅜-in. bars (*b*) at the same centres, making a series of ⅜-in. bars at 5-in. centres at the bottom, from which the number of each length required can be estimated by multiplying the length of the wall in feet by $\frac{12}{10}$. The number of fillet bars (*c*) required is the same as the total of the vertical wall bars ($a + b$).

The $\frac{5}{16}$-in. cross-bars should also be so arranged that they are as long as they conveniently can be to suit the length of the wall, say, about 20 ft., and the lap at the splice should not be less than 18 in. These laps should also be arranged so that they are spread evenly along the length of the wall and are not bunched together near any one section. The length of the wall should be drawn out to scale and the bars set out, measured off, and ordered accordingly. The total weight of steel per yard run of wall is approximately 40 lbs., including an allowance of 10 per cent. for crossbar laps.

For a wall of this nature the bars can be assembled in short units and lifted into the trench. Some or all of the wall crossbars may be omitted until the base has been concreted, but the tops of the ⅜-in. bars should be securely fastened to a wooden strip, which can form part of the framework, holding the reinforcement in position before the base is concreted and has set. It is very important that bars projecting from concrete—particularly green concrete—should not be disturbed.

Removal of Shuttering.

The wall will not reach its proper strength to resist earth thrust until at least six weeks have elapsed after concreting (or less with rapid-hardening cement), so that the future bank which has to be retained must not be filled in behind the wall until this period has passed unless the face shuttering be retained and strutted to take the earth thrust. When inserting this filling, coarse rubble or the largest stones available should be placed around and above the weep holes. The filling in front of the wall should, of course, be placed before that at the back, and be well consolidated as mentioned above.

WALL: OVERALL HEIGHT, 6 ft. 3 in.

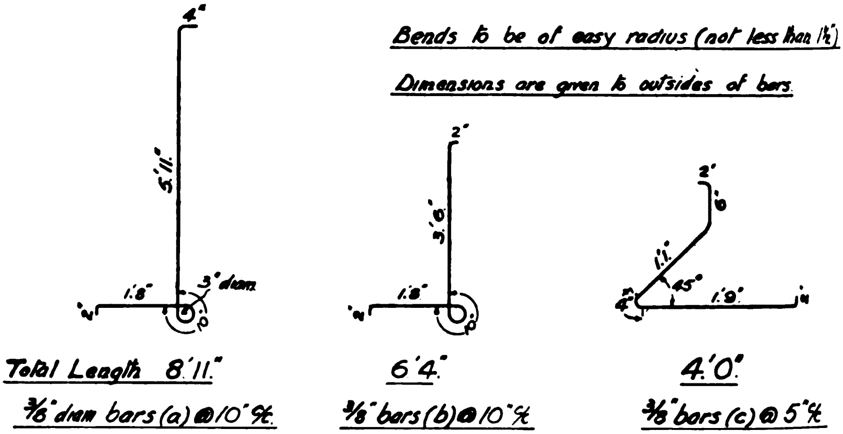
QUANTITIES PER LINEAR YARD OF WALL.

(Based on 1 : 2 : 4 : concrete.)

				cu. ft.
CONCRETE :—	Base . .	1 sq. yd.	4 in. thick	3·0
	Fillet . .	6 lin. ft.	4 in. by 4 in.	0·33
	Wall . .	2 sq. yds.	4 in.	6·00
	Coping . .	3 lin. ft.	6 in. by 2 in.	·25
				9·58

SHUTTERING :—Wall : 36 ft. super (both sides measured) net. Add for cutting, posts, struts, etc.

STEEL REINFORCEMENT :—


Bends to be of easy radius (not less than 1½")
Dimensions are given to outsides of bars.
4"
5'11"
1'8"
3" diam
2"
3'6"
1'8"
2"
6"
1'1"
45°
1'9"
4"
Total Length 8'11"
6'4"
4'0"
3/8" diam bars (a) @ 10" %
3/8" bars (b) @ 10" %
3/8" bars (c) @ 5" %

Cross bars—10 $\frac{5}{16}$ in. diam. per unit length of wall. (Add 1 ft. 6 in. to unit length for lap.)

Modifications for Lower Walls.

If the net height be considerably less than 4 ft. 6 in. the diameters of the bars may be reduced as shown in Table 1.

TABLE 1.—MODIFICATIONS FOR LOWER WALLS.

Height of Wall.	Diameter of Bars.	Width of Base.
(L.G.L. to H.G.L.)	(at 5 in. centres)	(See *Fig.* 1.)
4 ft. 6 in. to 3 ft. 9 in.	3/8 inch	2 ft. 0 in. heel and 1 ft. toe
3 ft. 9 in. to 3 ft. 0 in.	5/16 inch	2 ft. 0 in. heel and 9 in. toe
3 ft. 0 in. and below.	1/4 inch	1 ft. 9 in. heel and 9 in. toe

The spacing of the bars, diameter of crossbars, and thickness of concrete remain as indicated in *Figs.* 1 and 2, but the width of base may be decreased according to Table 1. The vertical and horizontal lengths of the main bars must therefore be adjusted to the new dimensions, but the 1 ft. 9 in. depth below L.G.L. should not be reduced.

Expansion Joints.

The necessity for expansion joints varies, of course, with circumstances, and would not arise at all in the case of short walls up to, say,

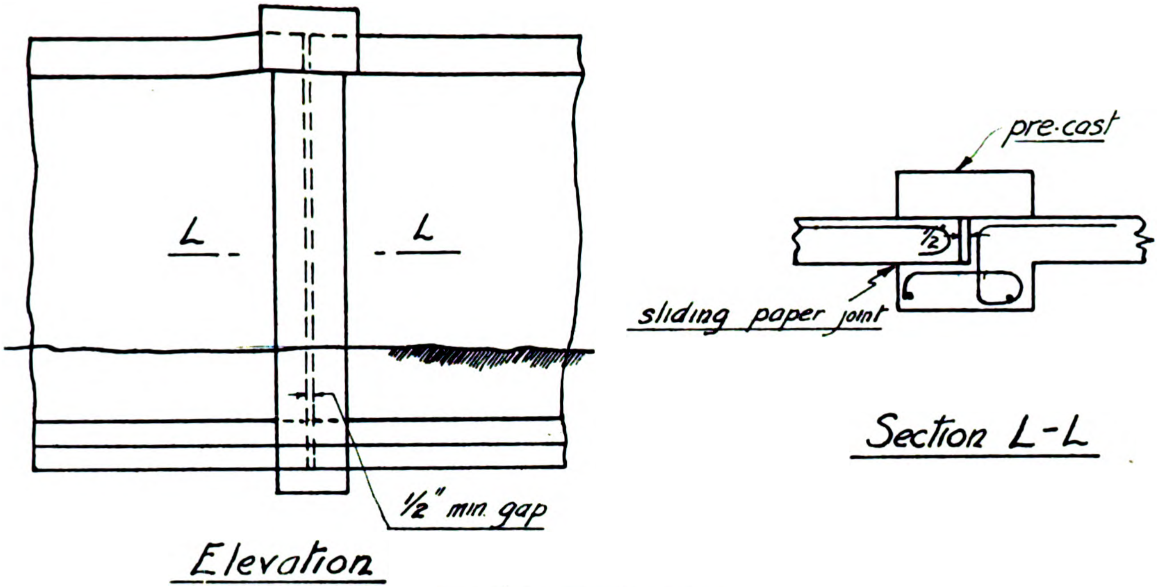


Fig. 4.—Expansion Joint.

50 or 60 ft. long. In long straight walls, however, joints should be provided at from about 100 ft. intervals for sheltered walls facing north to 50 ft. intervals for very exposed positions facing south. Many walls have, of course, been built with joints, if any, at much greater intervals; but a risk is involved if the limits are materially increased or the matter entirely ignored. On the other hand, the more joints provided the less will be the tendency for contraction cracks to appear.

Should it be desired to increase the intervals, the number of cross bars in the wall and coping should be increased in the same proportion as the interval is increased, and the crossbars placed equally along both surfaces of the wall.

A suitable joint is shown in *Fig.* 4, the gap between the ends of each section of wall being ½ in. This gap may be conveniently screened by a post, a series of which would be introduced to relieve the monotony of a long stretch of plain wall. The post may be pre-cast or cast *in situ* together with one section of the wall, while a paper or sliding joint is left against the adjacent section. In the case illustrated the joint is covered at the rear and under the base by a 4-in. pre-cast plank, which prevents soil entering and at the same time allows of free longitudinal movement due to temperature and humidity changes.

If the joint is not thoroughly cut off from the earth filling, or if there is any danger of it filling from any cause whatsoever, the gap should be filled with yielding material, such as a bituminous preparation, to exclude stones and soil and so ensure that it always functions properly.

It should be noted that all crossbars are to be well hooked at their ends abutting the joint.

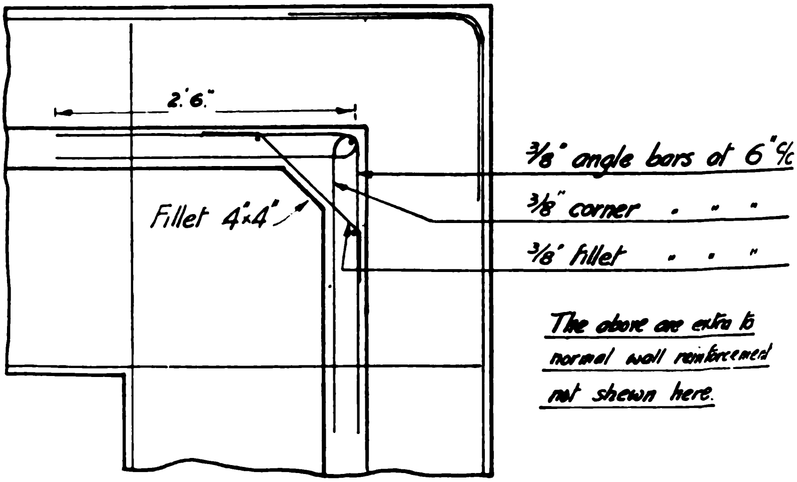

2'6"
Fillet 4"x4"
3/8" angle bars at 6" c/c
3/8" corner " " "
3/8" fillet " " "
The above are extra to normal wall reinforcement not shewn here.

Fig. 5.—Section through Corner.

Returns and Angles.

The stresses in a cantilever wall are entirely altered at any point of sharp change in direction on plan, and additional horizontal reinforcement is then required. If extra horizontal reinforcement is omitted or insufficient the wall must surely crack at, or near, the corner in order to adjust itself to the vertical reinforcement provided. The latter is, of course, sufficient from the point of view of safety but cannot prevent vertical cracks, which are defects to be foreseen and avoided.

For the walls described the following horizontal bars are required extra to the usual cross bars (which should be hooked at the corner). The shapes to which they are to be bent and their positions are given in *Fig.* 5. Each set of bars, consisting of $\frac{3}{8}$-in. corner, angle, and fillet bars, is to occur at 6-in. centres all the way up the corner. The cross-bars in the base should also be taken well on, and the outer one bent round the corner.

Sloping Sites.

More often than not it will be found that either or both the higher and lower ground lines are inclined when the wall is viewed in elevation. This introduces a difficulty in that the limits of heights and depths are soon outrun, as the base, except in very rare cases, must be maintained horizontal throughout. The base should therefore be stepped at intervals, as in the case of house footings on sloping sites.

The coping may follow the slope of the H.G.L., but a much better appearance will result if, when possible, the top is trimmed level to permit of the coping being horizontal. Both the top and base can then be stepped at regular intervals to accommodate the wall to the general slope, as shown in *Fig.* 6. There is an additional advantage in so doing, because the wall is constant in dimensions throughout the interval.

Practically each case will need individual treatment, so that an accurate survey must be made and plotted, and the wall drawn out

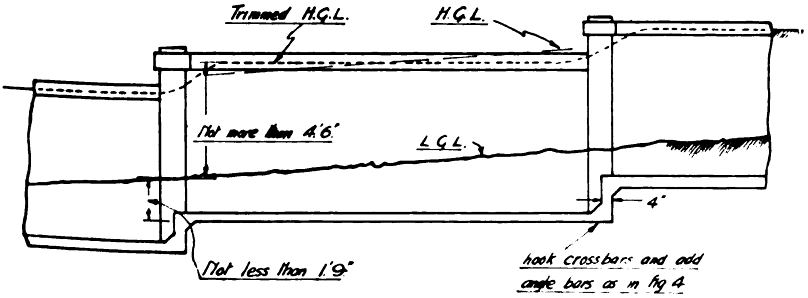


Fig. 6.—Wall on Sloping Ground.

so that its minimum depth below L.G.L. is 1 ft. 9 in., while its maximum net height must not exceed 4 ft. 6 in. Where the inclination is very marked and the foundation sound, the 1 ft. 9 in. depth may be reduced to 1 ft. 6 in., when continuous with a deeper base.

The junction at each step should be provided with a post or pillar of adequate width to correspond with the length of each section, and reinforced with a ⅜-in. bar at each corner with ¼-in. binders at 9-in. centres vertically. The normal wall reinforcement must, of course, be inserted, and not omitted for the width of the pillar, which is purely a decorative addition of no structural value. Expansion joints in a stepped wall would naturally be arranged to occur behind some of these posts.

Asphalted Concrete Piles.

In all new piling work under its jurisdiction, we understand the Los Angeles Harbour Board has decided to impregnate the concrete with asphalte to a depth of approximately 1½ in. from the surface in order to prevent deterioration in sea water, and a special plant, on the principle of a plant for creosoting wood poles, has been installed for the purpose.

The specification for the manufacture of these piles is as follows:

(1) A concrete mixture of 1 : 1½ : 3 is poured into horizontal wooden forms.

(2) A slightly drier mixture is used in the outer 2-in. rim of the pile, from a point 3 ft. below the low-water line to the top of the pile. This is accomplished by the use of steel plates, which are lifted during the pouring of the concrete.

(3) Pneumatic hammers are used on sides and top of forms to produce a vibratory action in the concrete, thus producing a dense mixture.

(4) The tiering of piling under construction is restricted to three tiers.

(5) Concrete piling is cured for a minimum period of 60 days, and on account of progress of treatment some piles are cured for as long a period as 130 days.

(6) Piles are then placed in an air preheater for 12 hours at a temperature ranging from 100 deg. F. to a maximum of 180 deg. F. Free water is driven off in this process.

(7) Piles are removed to asphalt-treating chamber.

(8) A 23-in. vacuum is maintained in the treating chamber for two hours.

(9) Asphalt is admitted to the treating chamber at a temperature of 180 deg. F. and increased to a maximum of 250 deg. F.

(10) Pressure of 150 lbs. per sq. in. is applied for eight hours.

(11) Asphalt and concrete piling is removed from treating chamber, piling being permitted to cool naturally.

A number of tests have been made on piles made and treated in this manner, which, owing to the rich mixture and the care in consolidation, have very high strengths.

A summary of average and maximum compressive strength for normal and treated concrete specimens tested is:

NORMAL CONCRETE.

Average Compressive Strength.

Age, Days.	Lbs. per Sq. In.
28	4,185
60	5,025
100	5,300

Maximum Compressive Strength.

Age, Days.	Lbs. per Sq. In.
28	5,570
60	6,240
100	7,100

TREATED CONCRETE.

Average Compressive Strength.
4,865 lbs. per sq. in.
Maximum Compressive Strength.
6,070 lbs. per sq. in.

Note.—Treated specimens vary in age from 60 to 100 days, the average age being 80 days.

It is expected that asphalte impregnated concrete made on these lines will be practically permanent in sea water.

DATA FOR PRICING REINFORCED CONCRETE.*

MATERIALS DELIVERED 4 MILES FROM CHARING CROSS.

		s.	d.
Best Washed Sand	per yard	16	0
Clean Shingle, ¾ in. mesh	,,	14	0
,, ,, ½ in. mesh	,,	15	6
Thames ballast	,,	10	6
Broken brick (¾ in.)	,,	11	6
Best British Portland Cement (delivered London area)	per ton	58s. to 63	6
Rapid-Hardening Portland Cement	delivered London 10s. per ton extra		
"Super-Cement"	per ton	88s. to 93	0
"Lightning" Brand Aluminous Cement	,,	100s. to 105	6
Ciment Fondu	works f.o.r.	95	0

BOARDING FOR SHUTTERING—

		Sawn. s.	Sawn. d.	Wrot. s.	Wrot. d.
1 in.	per square	23	6	27	6
1¼ in.	,,	29	6	33	6
1½ in.	,,	35	6	41	0

SAWN TIMBER FOR STRUTS AND SUPPORTS—

3 in. by 4 in.	from £22 per standard
3 in. by 6 in. and 3 in. by 7 in.	,, £20 ,, ,,

MILD STEEL RODS FOR REINFORCEMENT—

		s.	d.
⅝ in. to 2¾ in. Rounds	per cwt.	10	6
7/16 in. to ½ in. Rounds	,,	10	9
⅜ in. Rounds	,,	11	0
¼ in. Rounds	,,	12	0

Breeze Slabs per yd. super: 2 in., 1/11; 2½ in., 2/4; 3 in., 2/9; 4 in., 3/6.

MATERIAL AND LABOUR, INCLUDING 10 PER CENT. PROFIT.

(Based on Contracts up to £2,000.)

PORTLAND CEMENT CONCRETE WELL MIXED IN PROPORTION 1 : 2 : 4—

				s.	d.
Do	do.	in foundation	per foot cube	1	11
Do.	do.	in columns	,, ,,	2	1
Do.	do.	in beams	,, ,,	2	3
Do.	do.	in floor slabs 4 in. thick	per yard super	6	0
Do.	do.	in floor slabs 5 in. thick	,, ,,	7	6
Do.	do.	in floor slabs 6 in. thick	,, ,,	9	0
Do.	do.	in floor slabs 7 in. thick	,, ,,	10	6
Do.	do.	in walls 6 in. thick	,, ,,	8	8

(Add for hoisting 3s. 6d. per yard cube above ground-floor level. Add for "Ferrocrete" 1s. 10d. per yard cube.)

STEEL REINFORCEMENT, INCLUDING CUTTING, BENDING AND PUTTING INTO POSITION AND SECURING WITH STOUT BINDING WIRE—

		s.	d.
From ¼ in. to ⅜ in.	per cwt.	22	6
,, 7/16 in. to ½ in.	,,	21	6
,, ⅝ in. to 2¾ in.	,,	20	6

EXTRA LABOUR TO BENDS in ¼-in. rods, ½*d.*; ⅜-in. rods, 1*d.*; ½-in. rods, 1¼*d.*; ⅝-in. rods, 1½*d.*; ¾-in. rods, 1¾*d.*; ⅞-in. rods, 2*d.*; 1-in. rods, 2¼*d.*; 1⅛-in. rods, 3*d.*; 1¼-in. rods, 3½*d.*; 1⅜-in. rods, 4½*d.*; 1½-in. rods, 6*d.* (per bend per cwt.).

EXTRA LABOUR TO HOOK BENDS: ¼ in., 1*d.*; ⅜ in., 2*d.*; ½ in., 2½*d.*; ⅝ in., 3*d.*; ¾ in., 3½*d.*; ⅞ in., 4*d.*; 1 in., 4½*d.*; 1⅛ in., 6*d.*; 1¼ in., 7*d.* (per bend per cwt.).

SHUTTERING—

		s.	d.
Shuttering and Supports for Concrete Walls (both sides measured)	per square	59	0
Centering to Soffits of Reinforced Concrete Floors and Strutting, average 10 ft. high	per square	55	0
Do. do. in small quantities	per ft. super	0	10
Shuttering and Supports to Stanchions for easy removal, average 18 in. by 18 in.	per ft. super	0	11½
Do. do. as last, in narrow widths	,, ,,	1	1½
Do. do. to sides and soffits of beams, average 9 in. by 12 in.	,, ,,	1	1½
Do. do. as last, in narrow widths	,, ,,	1	3½
Raking, cutting, and waste to shuttering	per ft. run	0	3
Labour, splay on ditto	,, ,,	0	2
Small angle fillets fixed to internal angles of shuttering to form chamfer	,, ,,	0	3

WAGES.—The rates of wages on which the above prices are based are:—Carpenters and joiners, 1/9½ per hour; Carpenters working on old shuttering, 1/10½; Labourers on building works, 1/4½; Men on mixers and hoists, 1/5½; Bar-benders, 1/5½.

[* This Data is specially compiled for *Concrete and Constructional Engineering*, and is strictly copyright.]

Prospective New Concrete Work.

Airdrie.—*Houses.*—The T.C. is considering a scheme for the erection of 130 houses on a site near Woodburn Avenue.

Altrincham.—*Houses.*—The U.D.C. proposes to build 40 houses on the Oldfield Brow estate.

Arlesey.—*Houses.*—The Biggleswade R.D.C. proposes to erect 20 houses each at Arlesey, Potton, and Stotfold.

Aylsham.—*Houses.*—The R.D.C. has applied for permission to erect 66 houses in various parts of the rural area.

Barnsley.—*Houses.*—The Corporation proposes to build 500 houses.

Bethesda. — *Concrete Houses.* — The U.D.C. proposes to erect concrete houses.

Billingham. — *Houses.* — Application has been made for permission to build 120 houses on the High Clarence Road site.

Bishop's Green.—*Bridge.*—The Kingsclere R.D.C. proposes to construct a bridge at Bishop's Green.

Bourne.—*Road.*—The U.D.C. has forwarded to the M.T. a scheme for the construction of a road connecting Bourne North Fen and South Fen.

Bradford. — *Houses.* — The Corporation proposes to build 326 houses, at an estimated cost of £132,500.

Bramhall.—*Footbridge.*—The L.M. & S. Railway Co. has been asked to provide a footbridge over the level crossing at Cock Walk.

Burgess Hill.—*Houses.*—The U.D.C. proposes to erect 30 houses.

Caerphilly.—*Reservoir.*—The U.D.C. will hold a conference with the Rhymney Valley Water Board in connection with a proposal to construct a reservoir.

Carlisle.—*Houses.*—The Corporation proposes to build 300 houses.

Colchester.—*Houses.*—The Housing Committee has recommended the T.C. to erect 70 houses in Ipswich Road. The cost is estimated at £32,650.

Colchester.—*Road.*—The Corporation proposes to spend £2,115 on the construction of a road to connect Cambridge and Maldon Roads.

Colne.—*Houses.*—The T.C. is preparing a scheme for the erection of 100 houses on the Holme Farm estate.

Cookstown. — *Houses.* — The R.D.C. has applied for sanction to erect 86 houses.

Crediton.—*Houses.*—The U.D.C. has instructed the Surveyor to prepare plans for the erection of 25 houses.

Gloucester.—*Houses.*—The Housing Committee has recommended the Corporation to erect 360 houses.

Grimethorpe.—*Houses.*—The Parish Council has recommended the R.D.C. to build 100 houses.

Harrow.—*Houses.*—The U.D.C. has applied for permission to borrow £88,150 for a housing scheme on an estate at South Harrow.

Hetton.—*Houses.*—The U.D.C. has applied for permission to build 100 houses.

Kinghorn.—*Houses.*—The T.C. has applied for sanction to borrow £16,000 for building 40 three-roomed houses in Baliol Street.

Leeds.—*Houses.*—The Corporation has applied for sanction to borrow £58,000 for the erection of 122 houses on the Meanwood estate.

March. — *Houses.* — Application has been made for sanction to build 50 houses in Upwell Road.

Poole.—*Bridge.*—The T.C. is considering a scheme for the construction of a bridge and street to replace the level crossings in Towngate and High Streets.

Rhyl.—*Pier.*—The U.D.C. has applied for sanction to borrow £11,000 for the reconstruction of the pier.

Rochford.—*Houses.*—The R.D.C. proposes to build 92 houses in the rural district.

Ross.—*Houses.* — The U.D.C. is considering schemes submitted for the erection of 50 houses.

Smethwick.—*Road.*—Application has been made for sanction to borrow £3,695 for the construction of a 50-ft. road from Cemetery Road to Church Road.

Stamford.—*Road.*—A by-pass road is to be constructed to relieve the traffic on the Great North Road.

Swarby. — *Bridge.* — The Sleaford R.D.C. proposes to spend £130 on the construction of a bridge at Swarby Ford.

Tipton. — *Bridge.* — The U.D.C. proposes to construct a bridge over the Canal in Sheepwash Lane.

Wakefield. — *Houses.* — The Council has applied for permission to borrow £79,750 for the erection of 150 houses at Snapethorpe.

Walsall.—*Houses.*—The T.C. is considering a proposal to erect 500 houses.

Yarmouth, I.O.W.—*Sea Wall.*—The I.O.W. County Council proposes to construct a sea wall at Yarmouth Common Road.

Tenders Accepted.

CHIPPING NORTON.—*Concrete Houses.*—The U.D.C. is seeking sanction to accept a proposal of the Universal Housing Co. to erect 14 concrete houses, at a cost of £5,850.

CHORLEY.—*Baths.*—The Corporation has accepted the tender of Messrs. John Dickinson & Co., Ltd., Bolton, for reinforced concrete work in connection with the construction of the new baths.

EMSWORTH. — *Concrete Wall.* — The Warblington R.D.C. has accepted the tender of Mr. C. J. Jones, Southbourne, near Emsworth, at £375, for the construction of a reinforced concrete retaining wall.

FULHAM (LONDON).—*Concrete Wall.*—The B.C. has recommended for acceptance the tender of Messrs. J. Mears, Ltd., at £215, for the supply of concrete blocks for a boundary wall at the North Sheen Cemetery.

HALSTOW, KENT.—*Concrete Tubes.*—The Commissioners of Sewers have accepted the tender of Messrs. Mears Bros., Lewisham, S.E., at £365, for the construction of a new sluice of concrete tubes with head and wing walls, etc. Other tenders submitted: A. E. J. Price, £419; E. Weavers, £600; J. Shelbourne & Co., £843.

HULL.—*Concrete Bridge.*—The Corporation has accepted the tender of Mr. I. Robinson, 14, Aylesford Street, Hull, for the construction of a reinforced concrete bridge and sewer syphon across the Cottingham drain at Inglemire Lane.

LEAMINGTON.—*Sewage Disposal Works.*—The Corporation has accepted the tender of Messrs. G. Law, Ltd., Kidderminster, at £57,509, for the construction of sewage disposal works, including sedimentation tanks in mass concrete; three humus tanks, each 32 ft. sq., in mass concrete; and 14 circular filter beds.

LEWES.—*Concrete Houses.*—The T.C. has recommended for acceptance the tender of the Universal Housing Co., Ltd., at £8,280, for the construction of 20 concrete houses.

MORDEN (SURREY).—*Concrete Houses.*—The U.D.C. has accepted the following tenders of the Triangular Construction Co., Ltd.:—£18,079 for 38 concrete houses in Cannon Hill Lane; £29,920 for 62 concrete houses in Wheatley Avenue.

ROCHDALE.—*Bridge Extensions.*—The Corporation has accepted the tender of the Norwest Construction Co., Litherland, Liverpool, for constructing in re-

DUCKHAM'S
CONCRETE
MOULD
OIL

GOES FARTHEST
FUNCTIONS BEST

ALEXANDER DUCKHAM & Co., Ltd.
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MANCHESTER MUNICIPAL
COLLEGE OF TECHNOLOGY
DEPARTMENT OF BUILDING
SESSION 1927-28

FULL-TIME DAY COURSES

The Department provides a Full-time Day Course in Building Technology, extending over a period of three years, for those intending to enter the Building Industry in a supervisory or administrative capacity.

The course provides a broad groundwork of general knowledge relating to the functions and organisation of the Building Industry and will equip the student for the development of specialised work in any branch of the Industry, including Structural Steelwork and Reinforced Concrete as applied to Building Construction.

Certificates are granted to students who satisfactorily complete the course.

A candidate for admission to the course will be required to pass an Entrance Examination and must be not less than 16 years of age at the time of entrance. Examinations will be held in September and October.

PART-TIME DAY COURSES

Part-time Day Courses are provided in Structural Engineering, Reinforced Concrete Engineering and Building Construction.

The Session begins on 3rd October, 1927.

Prospectus forwarded free on application to the Registrar, College of Technology, Manchester.

inforced concrete and brickwork the extensions of the bridge over the Rochdale Canal at Manchester Road, Castleton.

SANQUHAR.—*Concrete Houses.*—The T.C. has accepted a tender for the construction of 12 concrete houses. The houses will be erected on the "McConnel" system, and will cost £315 each.

TIVERTON.—*Concrete Houses.*—The R.D.C. has accepted the tender of Messrs. Andrews & Miller, Ufficulme, at £18,208, for the construction of 50 concrete houses.

UTTOXETER.—*Concrete Swimming Bath.*—The U.D.C. has accepted the tender of Mr. W. A. Porter, Bagots Bromley Farm, Staffs., at £1,595, for the construction of a reinforced concrete swimming bath, 160 ft. by 50 ft. by 5 ft. deep. Other tenders submitted: Ward & Godbehere, £1,774; Fram Reinforced Concrete Co., £1,822; E. E. Jeavons & Co., Ltd., £1,919; Bridge & Engineering Co., £2,005; Cumberland Reinforced Concrete Co., £2,239; A. Blair Lyell & Co., £2,301; G. P. Trentham, Ltd., £2,381; F. Mitchell & Sons, Ltd., £2,437; H. Middleton, £2,617; H. Coxhead & Co., £2,990; T. W. Pedrette, £3,145.

WAKEFIELD.—*Pipe Line.*—The T.C. has accepted the tender of Messrs. Fred Whitaker & Co., Ltd., Leeds, for reinforced concrete work in connection with the Ryburn pipe line.

WITHERIDGE.—*Concrete Bridge.*—The S. Molton R.D.C. has accepted the tender of Messrs. Fothergill Bros., Ltd., Exeter, at £1,908, for the construction of a reinforced concrete bridge and culvert at Bradford Mill, Witheridge.

New Companies Registered.

BRITISH CONCRETE BREAKING CO., LTD. (221386). Registered April 23. Concrete, demolition and general contractors, Corporation Chambers, Corporation Street, Bolton. Nominal capital: £2,000. Directors: J. Makin, 32, Ainsdale Road, Bolton; W. Hodkinson, 280, Chorley Road, Westhoughton.

GREAVES, BULL & LAKIN (HARBURY WORKS) LTD. (221502), 20, Buckingham Gate, S.W.1. Registered April 29. Manufacturers of cement, etc. Nominal capital: £400,000. Directors: H. S. Horne, 27, Park Street; W. J. T. Phelan, 2, Palace Place Mansions, Kensington, W.8; O. J. S. Piper, Ship House, 20, Buckingham Gate; S.W.1; Lord Stanmore, Goldings Manor, Loughton, Essex.

LION CONCRETE PRODUCTS, LTD. (221778). Registered May 12. Nominal capital: £2,000. Directors: J. B. Lee, 1, Victoria Walk, Horsforth; T. Hargreaves, Keldholme, Harrogate Road, Leeds; N. Braithwaite, "Ashville," Woodside, Horsforth; S. Facer, Villette, Brownberrie Lane, Horsforth.

SURREY CONCRETE PRODUCTS LTD. (222040). Registered May 23. Peasemarsh, near Guildford, Surrey. Nominal capital: £2,500. Directors: L. G. Bell. "Northbank," Farnham Road, Guildford; H. L. Bell, G. A. Bell and Alice M. Bell, of the same address; and J. Thomson, Hatfield, Waterden Road, Guildford.

Recent Patent Applications.

245,122.—J. W. Thompson: Concrete constructions.

262,394.—E. I. Lindman: Porous concrete.

263,124.—J. G. Farbenindustrie Akt-Ges: Production of cements.

267,927.—F. Moser: Concrete mixers.

268,015.—Concrete Ltd., J. G. Ambrose and C. B. Mathews: Concrete blocks.

268,121.—D. Johnston: Concrete blocks.

268,255.—A. J. H. Haddan: Distributing concrete.

269,974.—D. De Ros and F. Barton: Colouring cements.

270,013.—G. O. Case: Process of making concrete.

270,829.—British Reinforced Concrete Engineering Co., Ltd., and E. B. Hall: Reinforcement for concrete pipes.

270,863.—Chatwood Safe Co., Ltd., and H. S. Bruckshaw: Reinforcement for safes and strong-rooms.

270,932.—C. Pohlig: Concrete road surface.

270,956.—C. E. Holloway: Concrete structures.

270,973.—N. Harrison: Plant for the manufacture of concrete blocks.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XXII. No. 8. LONDON, AUGUST, 1927.

EDITORIAL NOTES.

Lime.

LIME is one of the most ancient of building materials. There is evidence of its use as long ago as 2000 B.C., yet it is one of the last of the building materials to emerge from the regions of tradition and rule-of-thumb, both in its manufacture and application. It might even be said that some of the better traditional methods have not been maintained, and as a consequence modern results in the preparation and use of lime are inferior to those of the ancients. This may well be so, because during the Roman era lime was not considered fit for use unless it had been slaked for three years, and modern methods of construction do not lend themselves to such thoroughness. The reason why lime has not advanced with other building materials in coming within the range of scientific control is perhaps because of the difficulties of applying scientific tests, and because lime is a product essentially for local consumption. The raw material for lime production, whether it be limestone or chalk, is well distributed over the country and the user of lime usually procures his supplies from the kilns on the nearest chalk or limestone beds, ignoring any classifications based on chemical analysis. Broadly speaking, the lime in each district is used for all purposes within the builder's requirements, although not complying with the specifications evolved by scientists for plastering, or alternatively for mortar work. As a rule the only test an ordinary user of lime wishes to apply is one for proper burning, and hitherto it has been considered that the eye is the only available judge of this quality. Hence it is probable that the simplicity of the requirements of the lime user, combined with the difficulties of correctly sampling a material in bulk ranging from powder to 6-in. pieces, have been the reasons for the tardy development of the industry.

A step in the right direction has now been taken by the Building Research Board in issuing a report on "Lime and Lime Mortars" (H.M. Stationery Office, price 1*s.* 9*d.*). This pamphlet does not embody the results of research by the Board, but is a collection of information derived from the ancient and modern literature of the world dealing with the uses and properties of lime. It constitutes in effect a text-book and should be valuable to the student of any age who wishes to obtain a fundamental knowledge of the subject. The classifications of lime form an important part of the pamphlet, and although there are admittedly three classes of lime—(1) pure white, or fat lime; (2) hydraulic lime with 20 or

30 per cent. of argillaceous constituents, and (3) a class intermediate between these two—as has been suggested, the builder will generally employ his local material for almost all purposes rather than pay extra transport charges to obtain a lime more suited to his particular need at the moment, which may be plastering (coarse or fine) or mortar.

The pamphlet includes specifications for lime which, although described as tentative, are somewhat ill-timed in view of the fact that a Committee of the British Engineering Standards Association is now working upon the drafting of a British Standard Specification. If such specifications as are put forward by the Building Research Board were adopted literally they would appear to be disastrous for some lime-burners, and would lead to increased cost in building. For example, for use in mortar, lime containing more than 85 per cent. of calcium oxide is not to be used except with pozzolanic additions such as burnt clay or crushed brick ; and for " fine stuff " for plastering it is stipulated that the lime must contain not less than 95 per cent. of oxides of calcium and magnesium. Such recommendations can only be adopted in some districts at additional expense in importing lime from distances, and they appear to ignore the fact that lime not complying with the specifications has been used for many centuries with acceptable results. The specifications are in fact counsels of perfection, and while probably leading to the production of better results in practice they must be adopted with great caution and with careful consideration of the existing conditions in the particular districts concerned.

Some prominence is given by the Building Research Board to pozzolanic materials which have the faculty of combining chemically with lime and forming a stronger mortar than lime and sand alone. Such additions to lime have not received much attention in this country because of the scarcity of suitable natural material, but on the Continent pozzolana, trass, and gaize, as they are variously known, are extensively used. Crushed brick is sometimes a suitable substitute for natural pozzolana, and apparently the Building Research Board is experimenting with artificially-prepared pozzolanas such as clay baked at certain temperatures.

One of the chief characteristics of lime is its plasticity, and this property becomes very important in plastering work. Until quite recently the plasterer himself was the only judge of plasticity, but the pamphlet describes an apparatus known as the Emley Plasticimeter which aims at a definite measurement of plasticity. If the apparatus gives results in line with the plasterer's judgment it will be a very substantial advance in the scientific control of lime production and application. The pamphlet sets out the advantages of using hydrated or ready-slaked lime in the form of a powder compared with the laborious and usually inefficient pond-slaking method that is adopted by the builder who buys lump lime. Chapters on the common faults in plastering with practical remedies and on the preparation of lime washes and cold-water paints are also useful parts of an interesting publication.

" Re-Tempering " Concrete.

It is one of the canons of good concrete making that the concrete must not be re-tempered, or " killed," implying that the concrete must not be disturbed after the setting of the cement has commenced. This is such a well-established axiom that when a concrete made with irreproachable materials fails to harden satisfactorily the reason generally accepted is that the cement must have been " killed." But those whose duty it is to report upon concrete failures, and who have been compelled to advance this time-honoured excuse in default of any other, have frequently felt uncomfortable on account of the evidence, known to the few who have studied the matter, which tends to show that the " killing " of concrete is not always so disastrous as the text-books and specifications suggest.

During the pre-British Standard Specification days, and during the period when medium-setting cement was in demand, thousands, if not millions, of tons of cement having initial setting times of ten minutes or less were used with complete satisfaction, and there can be no doubt that a large proportion of this cement was " killed " in use. Moreover, even at the present day it is a recognised part of the concrete floor-layer's art to apply the finishing touches to the floor after setting has commenced. Or again, one of the plasterer's devices for the patching of concrete is to mix concrete or mortar overnight, with the addition of a little alum to retard the setting, and then to re-gauge in the morning. Such mortar is, of course, thoroughly re-tempered, but it is claimed by the plasterer to be fatter and less liable to contraction than freshly mixed mortar, and therefore suitable for patching work. Actual experience goes to prove that the operation in skilled hands is a successful one. Finally, some interested in the subject of the re-tempering of concrete have gone farther, and have made laboratory tests of re-tempered concrete which in several cases have shown it to be stronger than concrete which has been treated in the orthodox way.

Up to the present these unorthodox views on the treatment of concrete have been kept in the background, but so far as America is concerned the " truth is out " because one of the foremost experts in America, Professor Duff Abrams, has publicly expressed the opinion that the old impressions concerning the subject of re-tempering are largely erroneous, and concrete would be improved by keeping for 30 minutes to three hours before placing. It would not be reasonable, however, to read this statement of Professor Abrams, nor to interpret the experiences referred to at the commencement of this note, as a justification for ignoring the old rules and permitting the setting time of cement to be entirely disregarded in the concrete-mixing operation. If concrete is to be re-tempered, the re-tempering must be done in a methodical manner. There is room for elementary research in this matter to determine the best conditions for re-tempering concrete, and with present knowledge all that can be safely said is that re-tempered concrete must not be allowed to become stiff or friable, but must be kept continuously plastic until finally placed in position. Second, once concrete has been mixed into the usual plastic consistency, no more water must be added ; if during the process of re-tempering the concrete cannot be kept plastic without the addition of more water, then the batch must be discarded.

The value of re-tempering probably lies in more intimate mixing, in more complete hydration of the cement particles, and a more complete absorption of the surplus water by the cement particles. The first two factors lead to additional strength, while the third factor of more complete absorption of water helps to reduce the contraction due to drying. It is important to remember, moreover, that re-tempered concrete is inevitably slower in hardening than normal concrete, and also there is greater need for more complete curing of the concrete after laying. Great care must be taken that the re-tempered concrete is kept continuously moist for a week. There is reason to believe that if the operation of concrete mixing could be continued, possibly intermittently, for several hours, the resultant concrete would be considerably better in the end, although slower in developing its strength. Any prolonged mixing of concrete does not commend itself under present conditions on the score of expense; but it is possible to visualise a new procedure whereby a larger bulk of concrete could be mixed for a longer period, thus tending to mass production on a larger scale, and so counteracting the heavier cost resulting from the greater expenditure of power in prolongation of mixing.

The comparatively small amount of experimental work that has been done suggests that all cements may not lend themselves to re-tempering, and those who may be tempted to apply the principles here referred to should be cautious in their operations. The concrete-making industry has not long emerged from the rule-of-thumb stage, and is still in its infancy as a scientific and controlled operation. Great possibilities can be seen in developments of the mixing process, and now that an opinion with authority behind it has been expressed on the subject of re-tempering, there is no reason why the matter should not be developed.

The New Horticultural Hall.

150-FEET SPAN GIRDERS CARRYING 270 TONS.

THE new Horticultural Hall, now nearing completion at Westminster for the Royal Horticultural Society, is of particular interest because its design both on the architectural and on the engineering sides contains unusual features. Some preliminary drawings of the work are given in our issue for May, 1926, and we are now able to give some further detail drawings (pp. 469–478).

The main hall contains a central bay 72 ft. in width by 150 ft. long, on each side of which is an aisle 26 ft. to 28 ft. wide. The central bay is spanned by concrete arches, 58 ft. high from ground floor level, which carry a series of clerestory

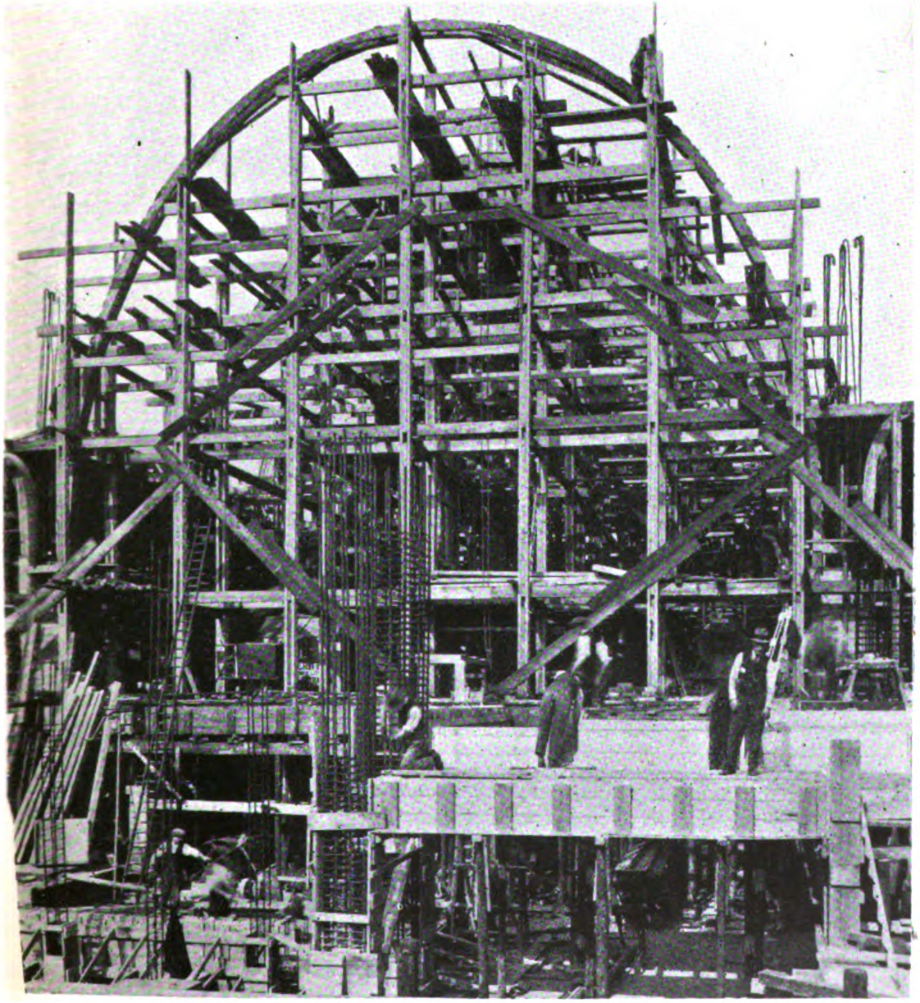


Fig. 1.—New Horticultural Hall during Construction.

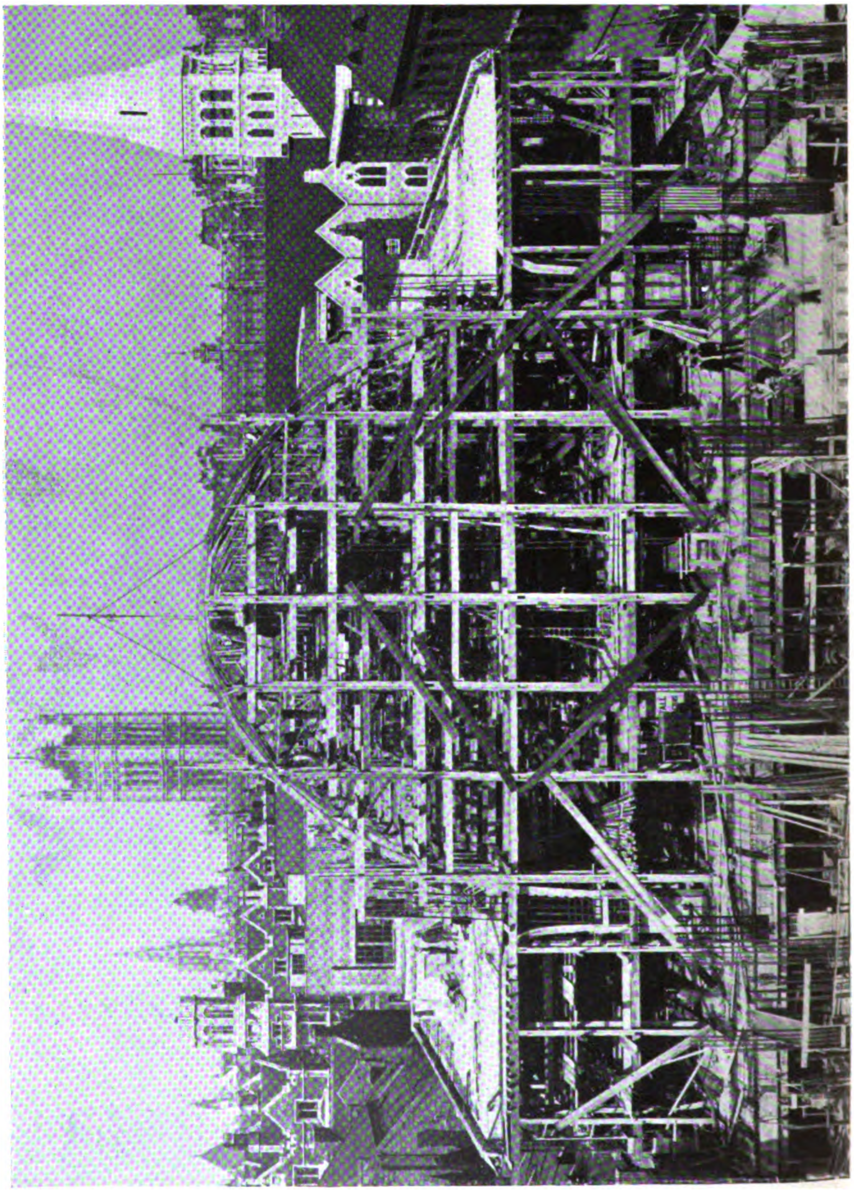
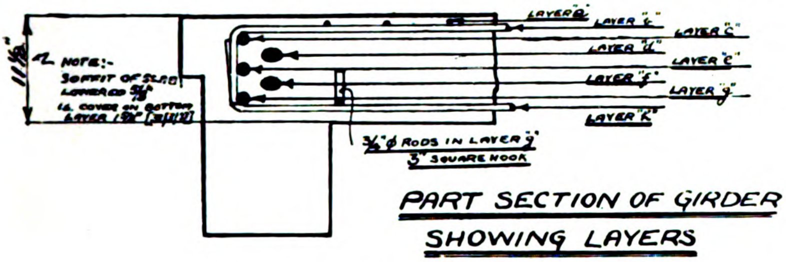


Fig. 2. New Horticultural Hall during Construction.

windows and roof flats forming a progression of steps, all of which are clearly indicated on the cross section in *Fig.* 5. The two side aisles are roofed with a horizontal concrete slab, which is pierced for overhead lighting.

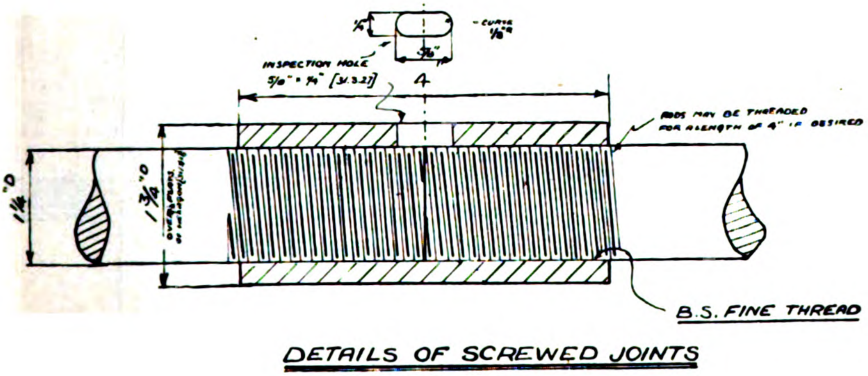
This special design, which resembles certain developments from abroad, is new to this country, and besides being of great interest architecturally serves to produce a most uniform and agreeable lighting to exhibits placed anywhere in the hall, and the architects are to be congratulated on the boldness and beauty of their design.

The chief interest of the work from the constructional point of view lies in the design of these arches and in the steps which have to be taken to provide them with suitable abutments to receive the thrust without departing from the arch lines which the architects desired. Had the arches been parabolic from ground floor upwards the thrust of the arch could of course have been resisted at ground floor level, where a suitable tie from side to side could have been accommodated. This, however, was architecturally undesirable and the actual form of arch was such that had it depended on a thrust at ground floor level for its stability the eccentricity of thrust (or the bending moment) near first floor level would have been so great that apart from cost the members could not have been made strong enough in anything like the space allowed for them. This difficulty could have been overcome if the thrust could be exerted at the level of the flat roof over the side halls, but the side aisles themselves have very little rigidity laterally and no tie across the centre bay at this level was permissible.



PART SECTION OF GIRDER SHOWING LAYERS

Fig. 3.



DETAILS OF SCREWED JOINTS

Fig. 4.

The problem was eventually solved by treating the flat roofs to the side halls

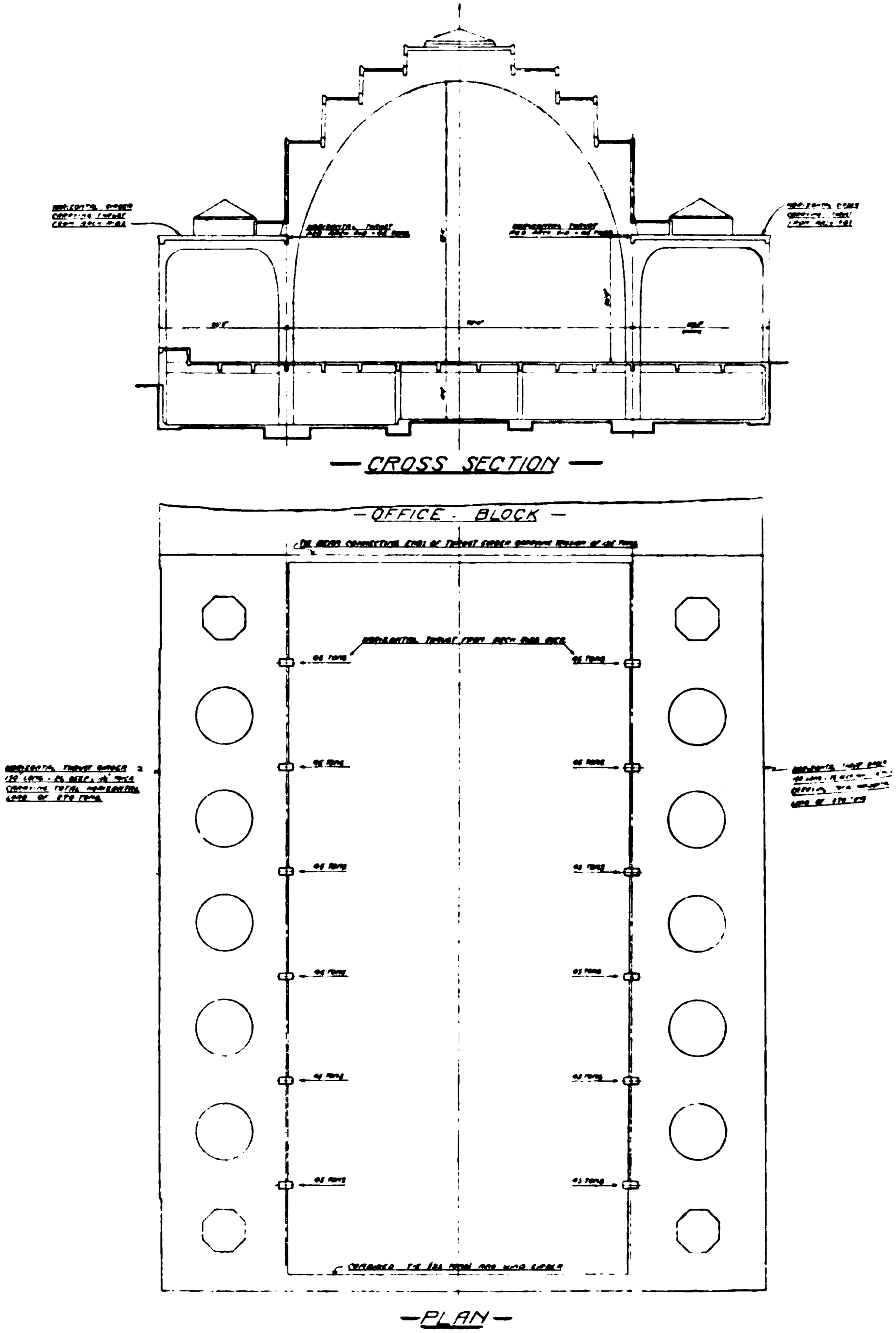


Fig. 5.—New Horticultural Hall: Plan and Section.

as horizontal girders of 150-ft. span and 26 to 28 ft. in depth. These girders receive at each pier the horizontal thrust from the arches and transmit it to the ends of the girders where the reaction is formed by reinforced concrete ties spanning right across the hall; ties in these positions were unobjectionable, as they could be accommodated in the end walls of the building. The horizontal thrust from each arch amounts to 45 tons, so that each girder has to carry a load of 270 tons on a 150-ft. span and the ties at the two ends each carry a load of 135 tons.

The details of the girders are shown in *Figs*. 3, 7 and 8, from which it can be seen that on the tension side of these girders there are thirty-three 1¼-in. main tension rods and on the compression side fifteen 1¼-in. main compression rods, in addition to transverse and diagonal shear reinforcements. As it was impossible in the space available to joint the main rods by lapping and hooking, and it would have been quite impracticable to make them the full length of the girder without joint, after careful consideration it was decided to connect these rods by screwing, as indicated in *Fig*. 4. The cost of the screwed ends has to be reckoned with, but at each joint a saving of 5 ft. or 6 ft. of rod is effected as well as the cost of forming the hook, even if space had been adequate to allow of lapping. The arrangement of rods is carefully designed so that as few screwed joints as possible occur in the same place, and not more than two out of eleven rows are screwed at any one section.

Tests on the screwed joints have been made and gave an ultimate strength of 28·4 tons for each screwed connection, which agrees well with the calculated strength. The flange force in each girder amounts to 600,000 lbs.

At one end of the building the tie connecting the two large horizontal girders is reinforced with eighteen 1¼-in. rods with screwed connections. At the other end the tie also has to act as a wind girder to resist the wind pressure on the great end wall of the hall; here it has to be increased considerably in size so as to resist the combined tension and bending, and it is 3 ft. 6 in. wide by 1 ft. 6 in. deep, reinforced with thirty-eight 1¼-in. rods.

Beyond the hall is the office block also constructed entirely of reinforced concrete.

The Architects are Messrs. Easton & Robertson, F. & A.R.I.B.A.; the Consulting Engineer is Dr. Oscar Faber, O.B.E., D.Sc., M.Inst.C.E.

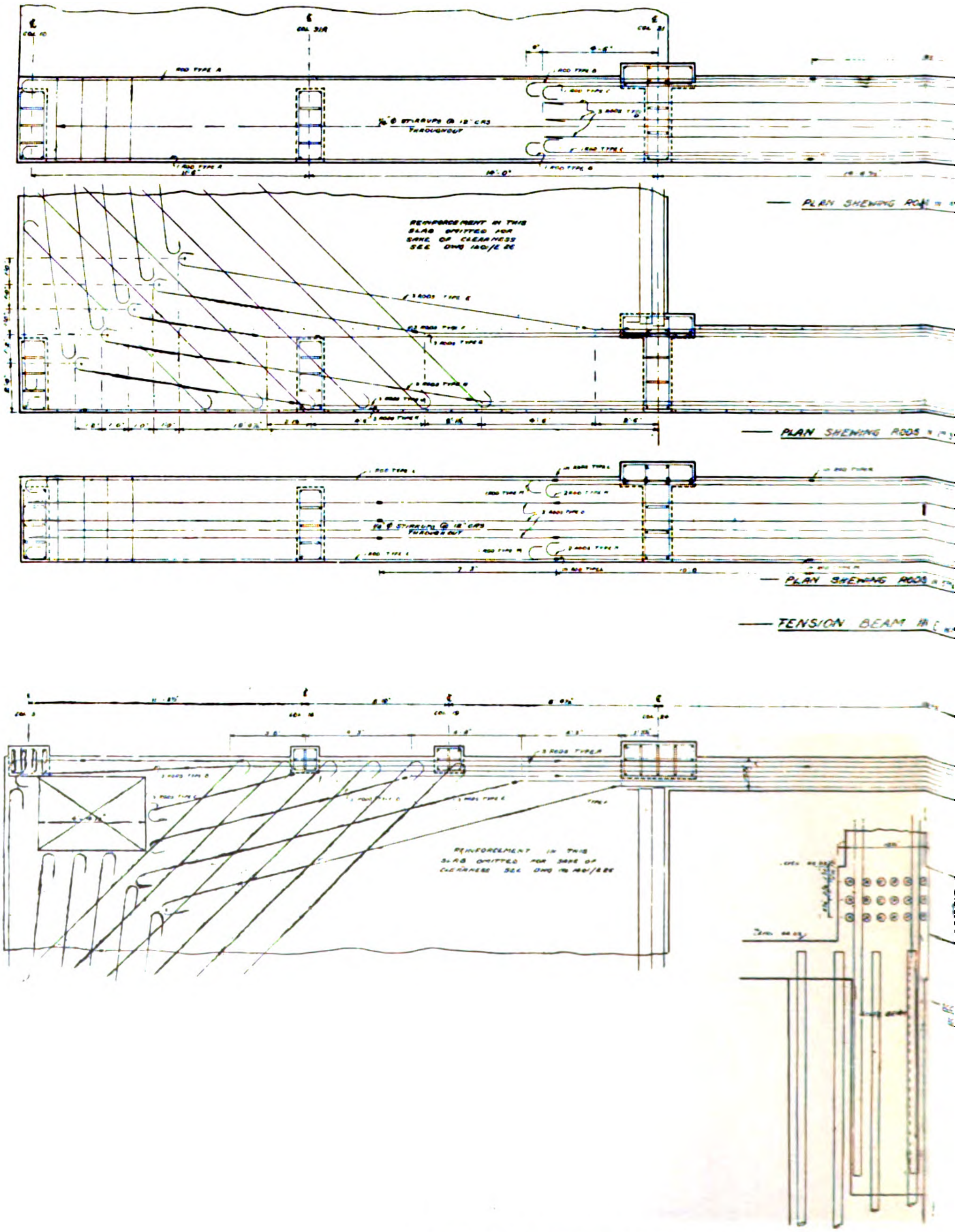
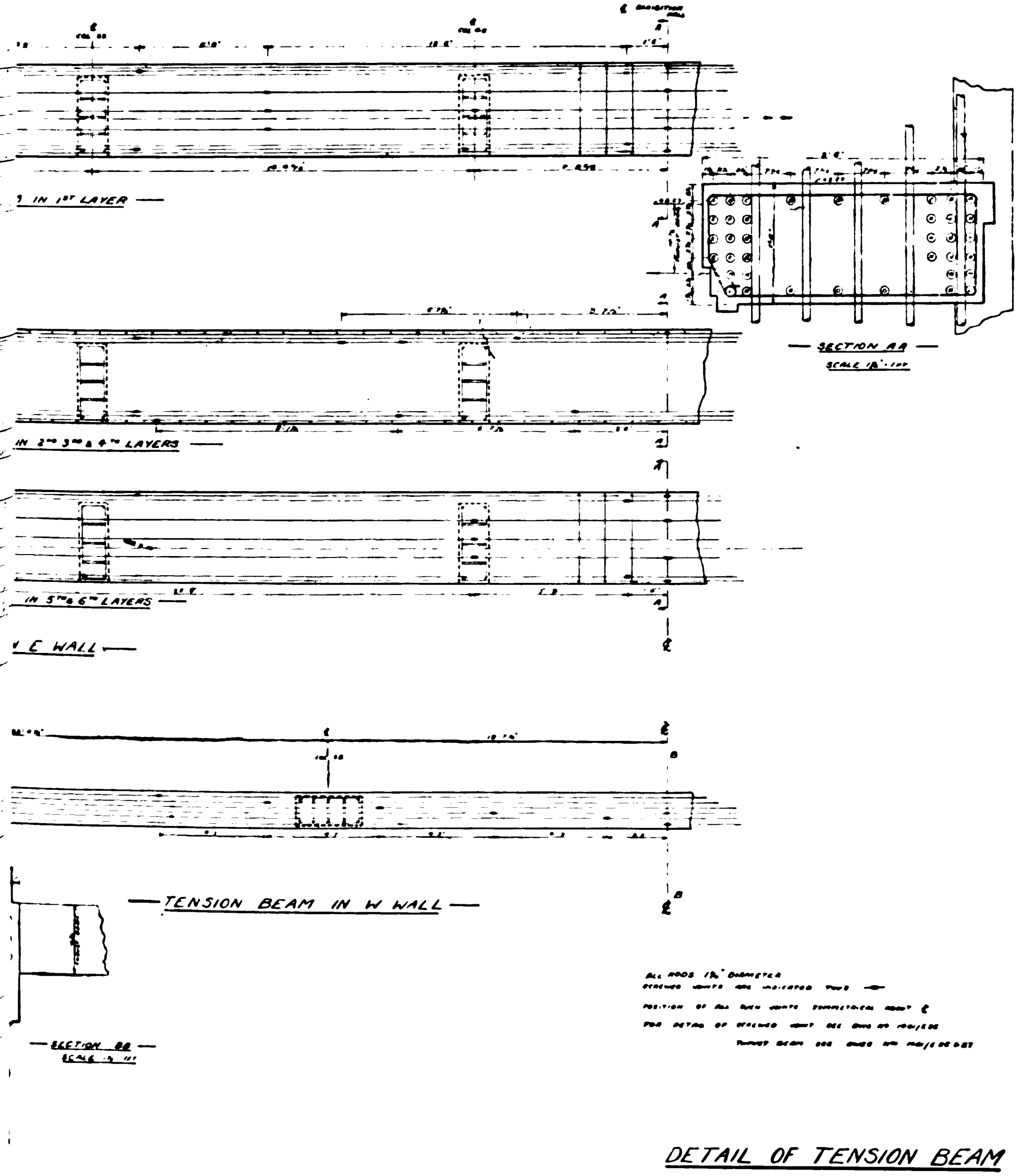

COL. 10
COL. 31A
COL. 31
ROD TYPE A
¾" Ø STIRRUPS @ 12" CRS THROUGHOUT
19'-0"
PLAN SHEWING RODS
REINFORCEMENT IN THIS SLAB OMITTED FOR SAKE OF CLEARNESS SEE DWG 1401/E 6E
3 RODS TYPE E
PLAN SHEWING RODS
PLAN SHEWING RODS
TENSION BEAM
COL. 3
COL. 18
COL. 19
COL. 20
REINFORCEMENT IN THIS SLAB OMITTED FOR SAKE OF CLEARNESS SEE DWG 1401/6 EE

Fig. 6.—NEW HORTICULTURAL HALL: D



ETAILS OF TENSION BEAMS. (*See p.* 469.)

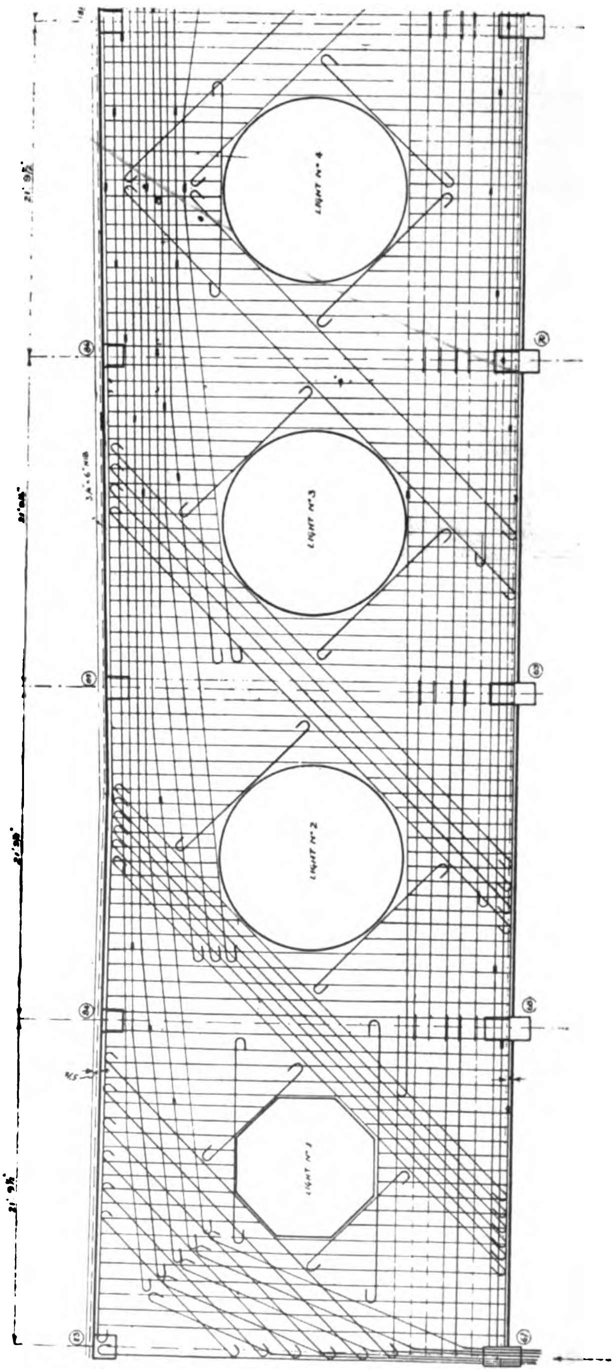


Fig. 7.—New Horticultural Hall: Part Section of Thrust Girder in North Aisle. *(See p. 469.)*

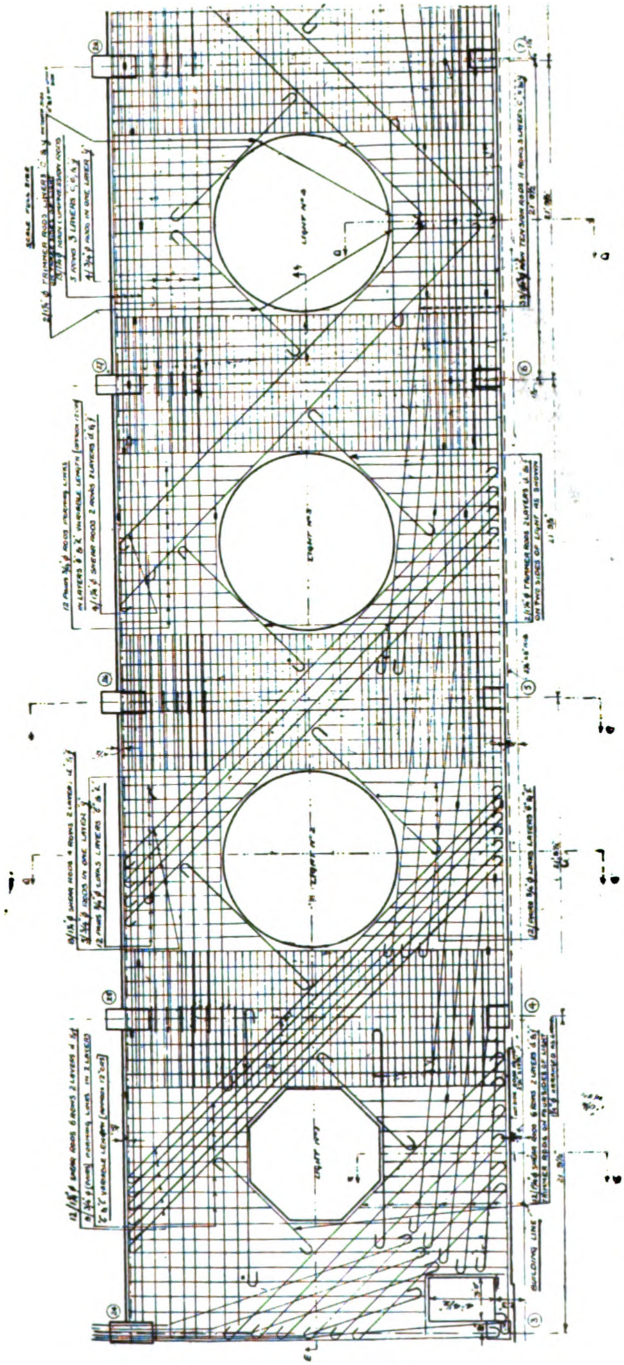


Fig. 8.—New Horticultural Hall: Part Section of Thrust Girder in South Aisle. (*See p.* 469.)

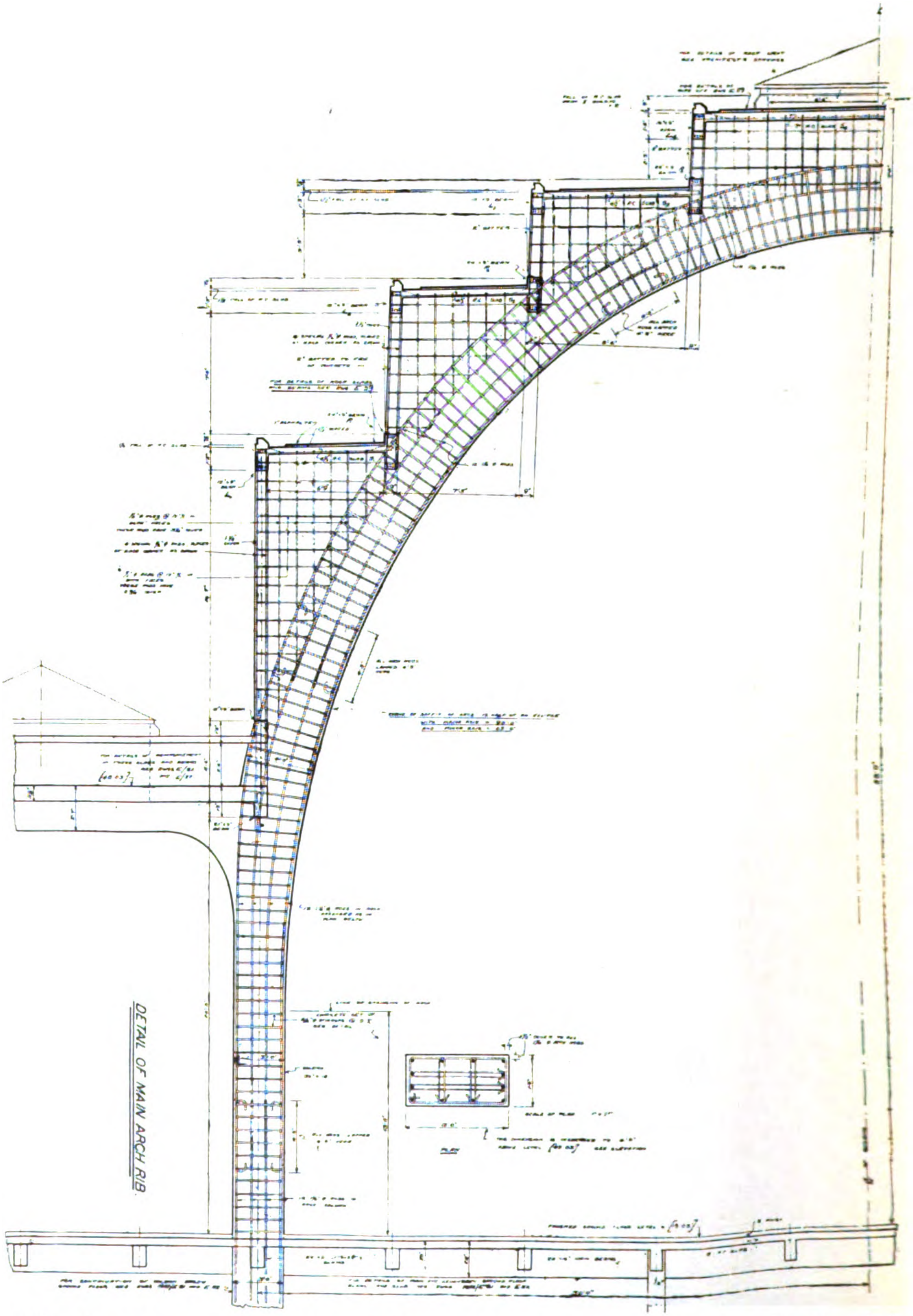


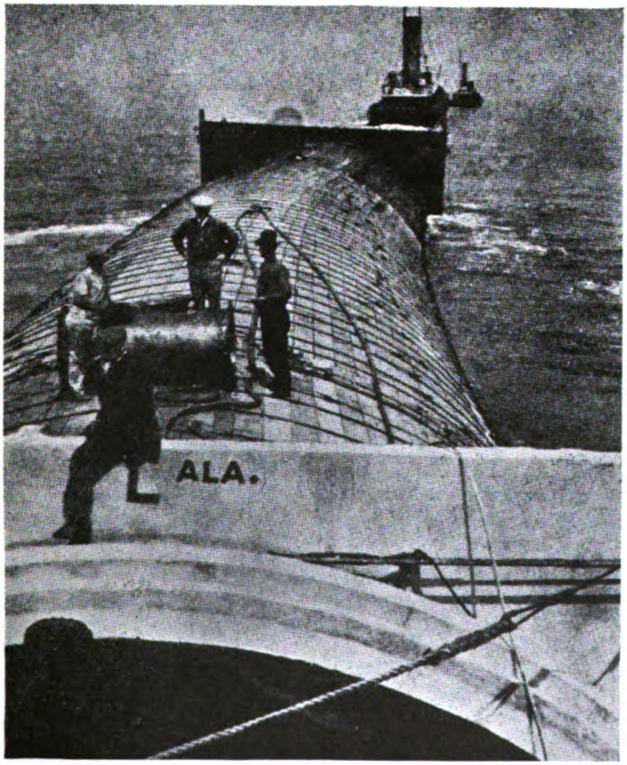
Fig. 9.—New Horticultural Hall: Detail of Main Arch Rib. (See p. 469.)

Pre-Cast Cylinders for 37-ft. Diameter Tunnel.

A TUNNEL, in which pre-cast concrete segments 203 ft. long by 37 ft. in diameter are being used, is now being built beneath the estuary that divides the cities of Oakland and Alameda, California. There are twelve of these large cylinders, which are being made on shore and towed to position. "Engineering News-Record," from which the following particulars of the work are taken, states that there is no precedent in floating such large pre-cast cylinders into place and sinking them into position. The walls of the cylinders are 2 ft. 6 in. thick, and temporary bulkheads are built on to them before floating, so as to keep them buoyant.

A trench with side slopes of about 1 to 1, was first dredged in the bottom of the river, and a layer of concrete 3 ft. thick placed in the bottom. At places, owing to the softness of the river-bed, piles were sunk to carry the cradle of the tunnel. The sides of the trench were covered with concrete 3 ft. thick, placed under water. Into the concrete cradle thus formed was placed a layer of sand 3 ft. thick to act as a cushion for the pre-cast cylinders.

The segments are towed into place and sunk. It is found that a layer of sand 4 ft. thick spread over the floor slab within the cylinder adds 50 tons to the weight of the cylinder, when it is wetted with water. Water is then admitted to the compartment beneath the floor slab until sufficient has been admitted to cause the cylinder to sink. After they have been sunk into position, more water is admitted so that they will be sufficiently heavy not to move. Sand is then



Towing Pre-cast Section to Site.

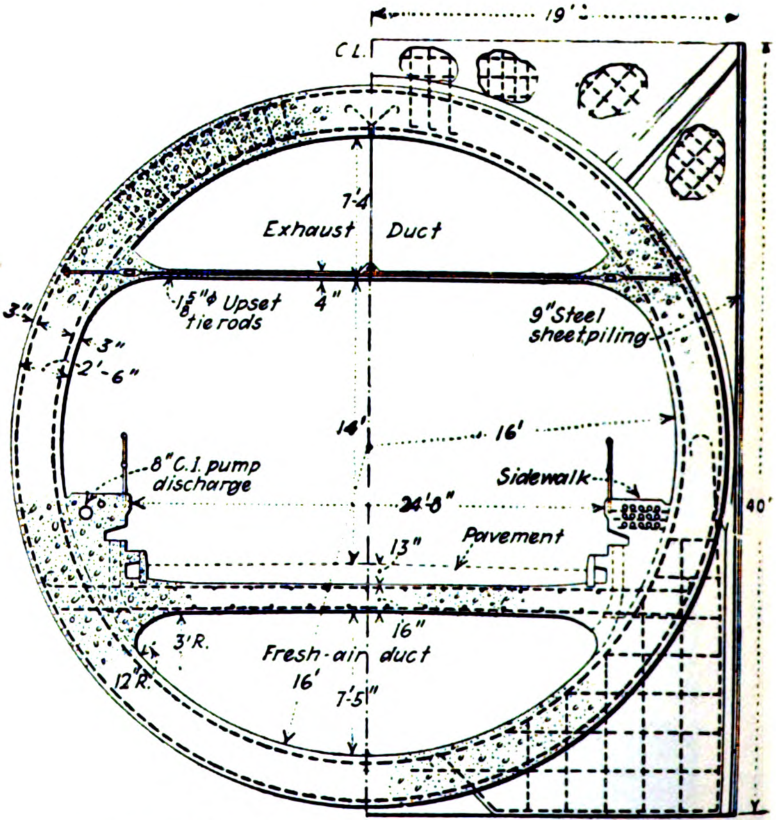
pumped into the space between the cylinders and the sides of the trench. Joints between the segments are made good by concrete placed beneath water.

For casting the cylinders use was made of two dry docks, about seven miles distant from the tunnel.

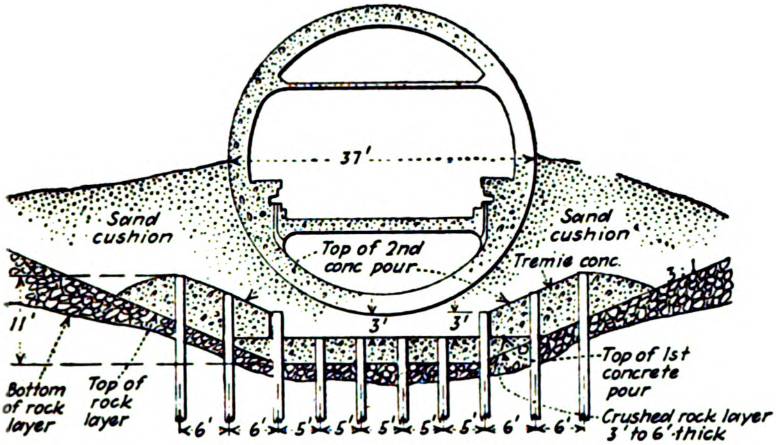
The dry dock, which was designed solely for vessels, has along its centre line as a keel support a heavy concrete pier below floor level. The concrete over the remainder of the bottom is only about 18 in. thick—not quite sufficient to carry the weight of the pre-cast sections. Hence 12 in. by 12 in. timbers were laid down on the floor as a foundation on which to place the concrete forms. These timbers were accurately spaced and levelled so that they would come under the semi-circular steel trusses which support the concrete forms in the lower half of the tube segments. Under the curved segments the timbers were arranged radially to conform to the radial location of the trusses.

These semi-circular trusses, 6½ ft. apart, support all concrete and forms below the horizontal diameter of the segments. On the inside faces of the trusses is a wood nailing strip to which a lagging of 2-in. by 12-in. planks is lightly tacked. On the inside of the lagging is placed a 3-ply waterproofing, consisting of impregnated cotton cloth capable of withstanding a pull of 90 lbs. per lineal inch. This cloth is embedded in four layers of asphalt mopped on hot, thus finishing the outer surface of the form against which concrete is to be poured.

The steel in the lower half or invert of



Section of Pre-Cast Tunnel Cylinder.



Section through River Bed and Tunnel.

the segment is then placed and the inner steel forms are jacked into position, after which the lower part of the cylindrical shell up to the floor level, and containing about 700 cu. yds., is poured in one continuous operation. After a period of three days for setting the floor slab is poured with the use of travelling forms made up into sections about 100 ft. long so that only two set-ups are required for each 203-ft. segment. With the exception of the centre support, each pour is given two days to set before moving the forms. When the slab floor is old enough to carry load, a wood-frame traveller, 100 ft. long and hinged at the crown, is placed on the floor and by means of jacks adjusted to position as a guide for placing the reinforcing steel of the upper half, or arch.

The outer forms for the upper half of the tube are much the same as those used below, except that the curve, of course, is inverted and the steel trusses form an arch. On the underside of the trusses 2-in. planking is used to complete the outer form.

Reinforcing steel in the arch is in the form of two grillages of ¾ to 1-in. steel bars, one near the outer surface and one near the inner face. The longitudinal bars are spaced on 6-in. centres and circumferential bars on 12-in. centres. The rods are kept 2½ in. from the forms by small concrete blocks wired to the reinforcement at 6-in. centres each way. The reinforcement is supported and held in place by bolts to fasten it to the trusses above. Concrete is poured through openings left in the planking.

After the concrete has set, planks and trusses are removed and then, unlike the procedure in the lower portion, the waterproofing and the timber lagging to protect the waterproofing are put on the upper half as a separate finishing operation.

Thus three separate pours are made on each 203-ft. segment; the first completes the invert up to the floor line, the second completes the floor slab, and the third (comprising about two-thirds of the shell) completes the arch After the sections are in position on the river bottom a fourth concreting operation is poured over the roadway to close it off from the air-passageways and the side walls.

Because of the large amount of steel, the limited clearances in the forms, and the difficulty of spreading, it was not easy to place the concrete, even with openings in the forms at four different levels. Pouring was therefore simplified by catching the concrete from the ends of the chutes in goose-neck funnels, through which it was led to openings in the forms and directed downwards inside them.

Steel forms, in 21-ft. sections, were used for the inner and outer shuttering of the upper portions of the cylinders, each section being hinged at the crown for convenience of moving. Between set-ups the inside forms move along tracks of 24-ft. gauge inside the tube and, when in place, vertical jacks raise the crown while others, placed horizontally, force the side walls out and hold them rigidly in the prescribed position.

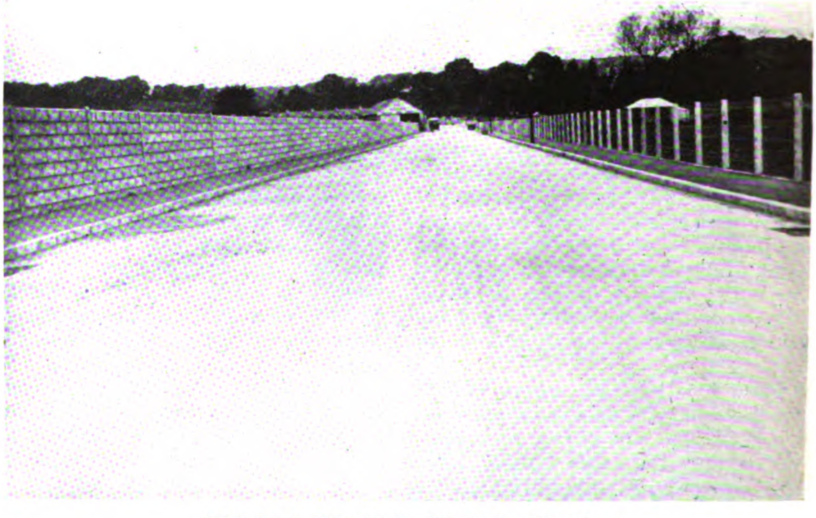
Some of the sections are curved. These are to fit a location laid out on a 1,273-ft. radius, but inside the tube this curve will be made up of a series of 21-ft. chords. That is, the steel forms are built on straight lines, and on the curve the forms will be set at a slight angle to make the desired curve, a wooden filler being put in between the ends of adjacent settings to take up the open space along the outer edge. This filler varies from a feather-edge at the inside of the curve to a width of about 10 or 12 in. on the outside.

Bideford-Northam Concrete Road.

THE Bideford and Northam by-pass road illustrated has been constructed partially on the old track of the Bideford, Northam, Westward Ho! and Appledore Railway, which was taken up and sent to France during the war.

The total cost of the road was approximately £30,000, and its length is about three-quarters of a mile. It is laid in two courses, with Bideford gravel for the aggregate of the bottom course and granite for the top course. Included in the work was the construction of three culverts of 10-ft. span, which were also carried out in reinforced concrete.

The concrete posts shown in the photograph were made by the contractors on the site, as also was the concrete kerb and edging. The wall on the left of the photograph is of *in situ* concrete, the "joints" shown being obtained by the use of V-shaped strips on the inside face of the shuttering. Beneath the road are concrete tubes from 9 in. to 30 in. diameter, made and supplied by the Manufactured Concrete Works, Ltd., of Barnstaple, who also supplied the pre-cast concrete manholes for this work. The road is reinforced with B.R.C. fabric.



Bideford–Northam Concrete Road.

The engineer for the work was Mr. R. S. Stone, Engineer of the Devon County Council Northern Division; Mr. F. J. Harris acted as resident engineer. The contractors were Messrs. S. & J. Smethurst, Ltd., of Oldham.

Efflorescence and the Fading of Coloured Concrete.

EFFLORESCENCE in its literal sense is the presence of flowery or snow-like bunches of white crystalline material on the edges and surface of concrete. It can only be derived from the materials in the concrete or from brickwork adjacent to it. Where the crystalline nature of the efflorescence is well pronounced it is generally found on chemical analysis that it is an alkaline salt, such as sulphate of soda, the origin of which must be sought in the constituents of the concrete.

Taking the three components of concrete, viz. aggregate, cement, and water, it is not usual to find alkalies in aggregates such as gravel, sand and stone, but broken brick and clinker occasionally contain alkalies giving rise to efflorescence. It is very rare for modern cements made from normal raw materials such as chalk, limestone, and clay to contain appreciable quantities of alkali, because the temperature of calcination is usually high enough to drive off any small percentage of alkali. Cement produced from by-product raw materials may be open to suspicion on this account, but chemical analysis of the cement will decide the point.

Water from springs, wells, and watercourses is usually free from proportions of alkali sufficient to cause efflorescence, but the use of sea-water with about 3 per cent. of soluble salts for mixing concrete may give rise to slight efflorescence.

Efflorescence of this nature is caused by the soluble salts in the concrete drying out on the surface. In some cases there is chemical interaction between the lime or gypsum in the cement and the alkaline salts in the aggregate or water, but the effect in the production of efflorescence is still the same. Such efflorescence is most prominent in new concrete, because on work exposed to the weather it is washed away by rain, although a fresh crop of incrustation is liable to appear again in dry weather until the whole of the soluble alkaline salts have been removed by weather. The efflorescence can be washed off with water, or better, with a weak solution of hydrochloric acid, as this will remove carbonate of lime which may also be present. Repeated washings are usually needed to get all the salts out of the concrete.

Efflorescence causing the fading of coloured concrete goods is of another order. Such goods are usually made of standard brands of cement, clean sand and pure water, and as the only abnormal addition has been the colouring matters, these have frequently been suspected as the cause of subsequent fading. Red oxide of iron, which is the most widely used pigment in concrete, is hardly likely to contain alkalies, and analyses of several samples from various quarters have eliminated it from suspicion as the cause of efflorescence or fading.

Analysis of the surface film of faded concrete tiles has shown it to be composed of carbonate of lime. It is generally agreed that set cement contains hydrate of lime which on exposure to the atmosphere is converted into carbonate of lime, but although this constitutes a reasonable explanation of the fading of concrete it does not give the reason for the fact that the phenomenon is spasmodic and not universal.

It is not an uncommon experience that one batch of concrete tiles will fade in course of time while others made at the same factory under apparently identical conditions retain their colour. Some manufacturers have been immune from the annoyance, while others using similar materials and methods have periodically suffered from the production of coloured concrete liable to fade.

Atmospheric conditions appear to constitute the only changing factor, and as a means of ascertaining the effect of extremes of atmospheric conditions coloured concrete goods of the same production have been preserved in the one case in an atmosphere free from carbon dioxide, and in the other case in air with an addition of carbon dioxide. In the former case there would be no opportunity of forming a film of carbonate of lime, while in the latter case there would be every inducement to do so. These experiments have shown, however, that red concrete tiles, whether preserved in an atmosphere of carbon dioxide or in an atmosphere free from carbon dioxide, retained their original bright colour.

It is certain that the tiles kept in an atmosphere of carbon dioxide must have acquired a layer of carbonate of lime at the surface, but evidently not of sufficient thickness to cause "fading." Thus by the process of elimination and reasoning the conclusion is reached that the discoloration or fading of coloured concrete only occurs when a sufficient quantity of carbonate of lime accumulates at the surface to obscure the original colour. This accumulation may be due to one of two causes; first, an undue proportion of cement (containing its percentage of hydrate of lime set free during setting) may have been brought to the surface by the use of an excess of water in the concrete or by excessive trowelling of the surface; or second, capillary action may, in a piece of concrete which is alternately wet and dry (such as under exposure to weather), cause the hydrate of lime which is disseminated throughout the concrete to come to the surface cumulatively until there is sufficient to form a white layer on carbonation and affect the colour.

The capillary action cannot take place if the concrete is dense and impermeable, and thus it is reasonable to assume that the spasmodic instances of fading tiles experienced by manufacturers are in most cases due to porosity. Such occasional porosity may be caused by the mortar being made too dry, or by insufficient cement, or by an unsuspected lack of finer particles in the sand. The prevention of fading therefore seems to be possible by maintaining a close supervision on the density of the concrete.

Questions and Answers relating to Reinforced Concrete.

Readers are cordially invited to send in questions relating to concrete. These questions will be replied to by an expert, and, as far as possible, answered at once direct and subsequently published where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—ED.

Loads on Slabs.

QUESTION.—In his article in your May number Mr. Ewart S. Andrews explains clearly how to determine the area over which a point load on a slab may be considered as being distributed. I wish to know how to find the bending moment for this load, or for any load which is distributed over part of a slab or beam; also how to treat the reinforcement required. Further, what is the proper method for finding the bending moment in the case of a rolling load, say a heavy lorry, on a slab? Is it correct to take it as

$$\frac{W(2l-a)^2}{16l}$$

where l = span; a = distance between loads?

In the case of a main beam carrying two or more concentrated or point loads, as from secondary beams, would it be correct to take the total of these loads and take the bending moment as being $\frac{Wl}{6}$ for a beam with free ends and $\frac{Wl}{9}$ for a continuous beam?

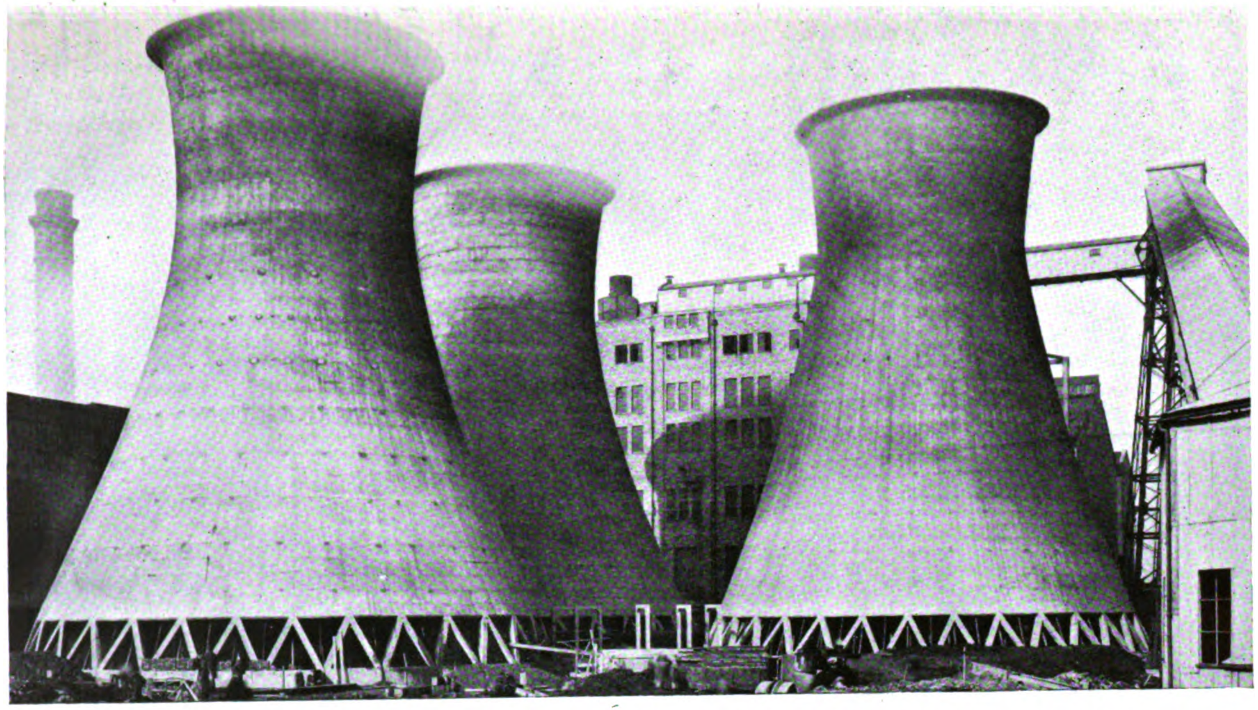
G. H. BRISCOE.

Conway.

ANSWER.—If the length of the load is c parallel to the span l, the maximum bending moment will be $\frac{W(2l-c)}{8}$, and if there are two equal loads each equal to W, at a distance a apart parallel to the span, the maximum bending moment will be $\frac{W(2l-a)^2}{8l}$; the formula quoted in the enquiry is correct if W is the total load.

The above values are those for a simply-supported span; for continuous spans suitable reduction should be made, and an approximation which is sufficiently accurate for most cases in practice is to take for a continuous span two-thirds of the bending moment for a simply-supported span.

In the case of the main beams carrying point loads from secondary beams, the correct bending moments to be taken will depend upon the number of points. In the case of secondary beams at the third points the formula given is approximately correct if W is the total load on the area supported by the main beam, but it is better to find the reactions coming from the secondary beams and find the bending moments on the main beams by the usual theoretical methods.—E. S. A.



Reinforced Concrete Cooling Towers at Liverpool.

[A description of these towers was given in our June number. The reinforced concrete design is by Messrs. L. G. Mouchel & Partners, Ltd.]

Economy of Rapid-Hardening Portland Cement.

In Germany, as in this country, there are on the market a number of cements with rapid-hardening properties and with higher resistance to stress than the ordinary Portland cement possesses. Special provision is made in the German regulations for the use of these cements in reinforced concrete work.

In Czechoslovakia the Government has lately carried out a series of experiments, under the direction of Professor Gessner, of Prague, in order to ascertain by how much the customary quantity of cement per cubic yard of concrete might be diminished if high-strength cements were substituted for ordinary Portlands. A full report, accompanied by tables and graphs of Professor Gessner's work, has now been published, and from this the following summary is compiled.

Two cements were tested, an ordinary Portland and a high-strength cement. The latter is denoted by the letter "A" in this article. The tests were carried out, using German standard sand and compacting the briquettes with the Böhme hammer. The results are given in Table 1 in lbs. per sq. in.

Table 1.

Age	2 days		7 days		28 days		28 days	
Cement	Tension	Compression	Tension	Compression	Tension	Compression	Tension	Compression
A	365	4250	430	6300	494	7460	535	8310
B	244	3130	324	4450	430	5250	580	7510
Storage	In water						Combined	

In testing the concretes, which were hand-mixed, four different mixes were used. These were 400, 360, 300 and 200 lbs. of cement to each cubic yard of concrete. With the richest concrete 15 per cent. by volume of water of the dry materials was used, and this percentage was reduced to 12·9, 10·6 and 8·2 with the leaner mixes; thus the water to cement ratio was kept constant.

For direct compression tests 4-in. cubes, cast in steel moulds, were employed. Control beams, made to Dr. Emperger's specification, were used to determine the compressive strength of the concrete when submitted to bending. Steel bars were cast in 4-inch concrete cubes in order to test the bond strength. Tables 2 and 3 record the results of the compressive tests.

It will be seen from Table 2 that when high-strength cement is substituted for Portland in members subjected to direct compression only, considerable economy results, as a leaner mix may be used. However, in the case of beams, the reduction of cement per cubic yard of concrete is more limited. Professor Gessner recommends a minimum cement ratio in this case of 360 lbs. per cubic yard, which roughly corresponds to a 1 : 3 : 6 mix.

Table 4 shows how rapidly the bond strength decreases as the mix employed is made leaner in cement.—W. S. G.

TABLE 2.—COMPRESSIVE STRENGTHS OF CUBES IN LBS. PER SQ. INCH.

Cement.	Lbs. of cement per cu. yd. of concrete.	Age in days.			
		2	7	21	42
A	400	1750	2400	3390	4650
	360	1270	1940	3120	3680
	300	739	1500	2710	2840
	200	610	1150	1860	2310
B	400	426	1410	1590	2000
	360	284	910	1270	1680
	300	256	840	1220	1350
	200	142	769	853	995

TABLE 3.—COMPRESSIVE STRENGTH IN BEAMS IN LBS. PER SQ. INCH.

Cement.	Lbs. of cement per cu. yd. of concrete.	Age in days.			
		2	7	21	42
A	400	1265	2030	4140	4350
	360	866	1820	3210	3710
	300	—	—	2910*	3140*
	200	—	—	1930*	3060
B	400	384	1150	1420	1622
	360	370	938	1360	1460
	300	—	—	952	1380*
	200	—	—	796*	853

* Denotes failure through bond stress.

TABLE 4.—BOND STRENGTH IN LBS. PER SQ. INCH.

Cement.	Lbs. of cement per cu. yd. of concrete.	Age in days.			
		2	7	21	42
A	400	376	456	535	690
	360	295	357	501	639
	300	196	315	370	541
	200	118	203	265	358
B	400	114	234	395	432
	360	106	182	275	332
	300	80	115	220	321
	200	39	95	136	264

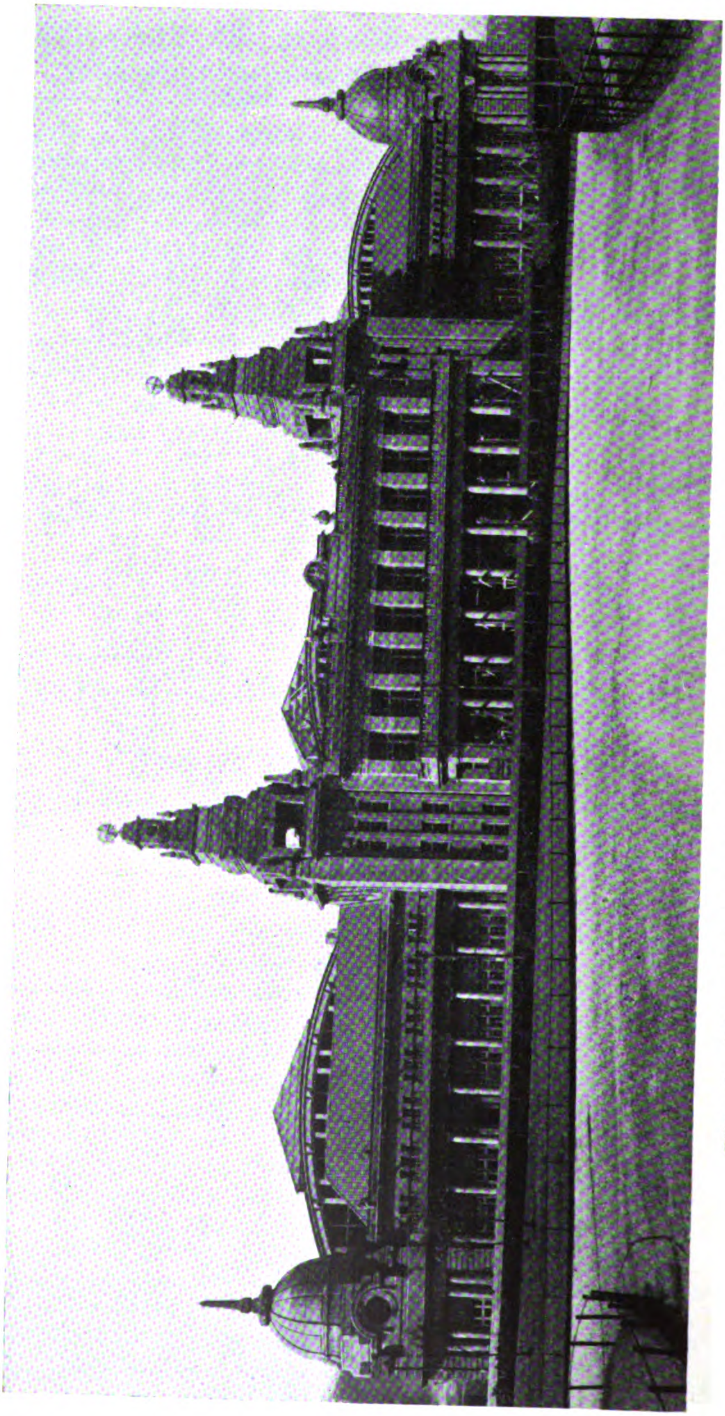


Fig. 2.—New Kelvin Hall, Glasgow: Main Elevation. (*See p.* 489.)

The New Kelvin Hall of Industries, Glasgow.

By W. L. SCOTT, M.Inst.C.E.

THE new Kelvin Hall of Industries is built upon the site of the former structure, which was destroyed by fire in July, 1925. The Corporation, at the outset, decided that the New Kelvin Hall must be a dignified edifice, fit to take its place in the important group of buildings in the immediate vicinity, and that it must be fireproof and thoroughly equipped. The City Engineer, Mr. Thomas Somers, M.Inst.C.E., was entrusted with the design and supervision of the erection of the new building.

The Argyle Street frontage of the new structure is set back to provide space on an island platform for pedestrians entering and leaving the building, and a carriage drive leads to a covered portico for motorists.

The building is in three distinct portions: (1) the Administrative Block abutting Argyle Street; (2) the Main or Exhibition Hall with its adjuncts, comprising tea room, platform, reception room; and (3) the store block, which includes the electricity sub-station on part of its lower ground floor.

Fig. 1 (pp. 506–7) gives the general plan of the building, and shows clearly the accommodation provided.

The red-sandstone front of the Administrative Block is colonnaded on the ground floor, and for this purpose the Doric order is employed. At each end a massive tower, surmounted by a lead-covered dome and obelisk, rises to a height of 65 ft. A pillared portico occupies the lower part of the centre of the frontage, behind which rises the wall of the conference hall. Two square towers, with vertical treatment to offset the horizontality of the frontage in general, rise to a height of 100 ft. Each tower terminates in a lead-covered lantern which supports a bronze Globe, symbolising the all-embracing and universal purpose of the new building. The lanterns can be illuminated at night. The attic stories of the wings have high-pitched roofs covered with red tiles.

Fig. 2 (p. 488) shows the Argyle Street frontage. The treatment of the external walls of the main hall is of a simple yet effective description, obtained by ordered fenestration and the use of bricks of various colours. The design of the doorways of the wide exits with their broad stairways expresses their secondary importance. The difficulties in designing these external walls may be appreciated when it is stated that the floor level of the main hall is 16 ft. lower than one point of Blantyre Street, and 14 ft. above a portion of Bunhouse Road; there is also a fall of 28 ft. in the frontage to Old Dumbarton Road.

Apart from the fact that this new exhibition building is probably the most up-to-date of its kind in existence, it is noteworthy both on account of the size of the main hall and the type of construction employed. The area enclosed by the walls of the main hall is 171,000 sq. ft. and is covered by three roof spans of 110 ft. and one span of 60 ft. The lengths normal to the spans are 458 ft. and 331 ft. respectively. For comparison it may be stated that the exhibition space of Olympia, including the new hall but excluding the gallery, is 212,380 ft. sq. The area of the Agricultural Hall, Islington, including the annex and arcade but excluding the gallery, is 128,300 sq. ft.

One of the main objects which had to be kept in view when designing the roof of the main hall was to have few pillars, and these as small in sectional area as possible compatible with strength. In this vast area, there are only twenty-two isolated columns; these are of reinforced concrete, octagonal in section, 24 in. in diameter.

Fig. 4 shows the interior of the main hall. The main roof, supporting columns and foundations, together with the skeleton framework, floors and roofs of the tea room, stores building, etc., are of reinforced concrete, the consulting engineers for which are Messrs. Considère Constructions, Limited, of Westminster. The whole of the reinforced concrete work in the Main Hall is entirely detached from the surrounding work.

The size of the various reinforced concrete members forming the roof trusses, valley beams, etc., have been kept down to the minimum consistent with safety. The entire structure of the main hall, including the external columns, gable ends, etc., is equivalent to a slab laid over the

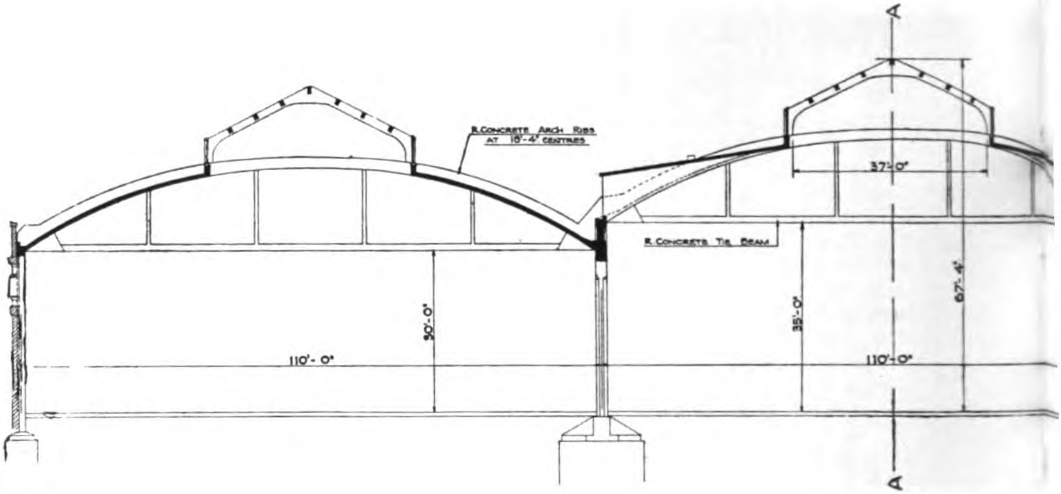


Fig. 3.—KELVIN HALL OF INDUSTRIES, GLASGO

floor 8½ in. thick. This thickness does not include the external walling or foundations, the latter of course depending upon the nature of material upon which they bear. This thickness of 8½ in. is exceptionally small having regard to the height of the roof, the distance from the floor to the intrados of the centre arched span being 52 ft. Moreover, the superload specified and allowed for is equivalent to a crowd of 50,000 adults standing on the roof at the same time.

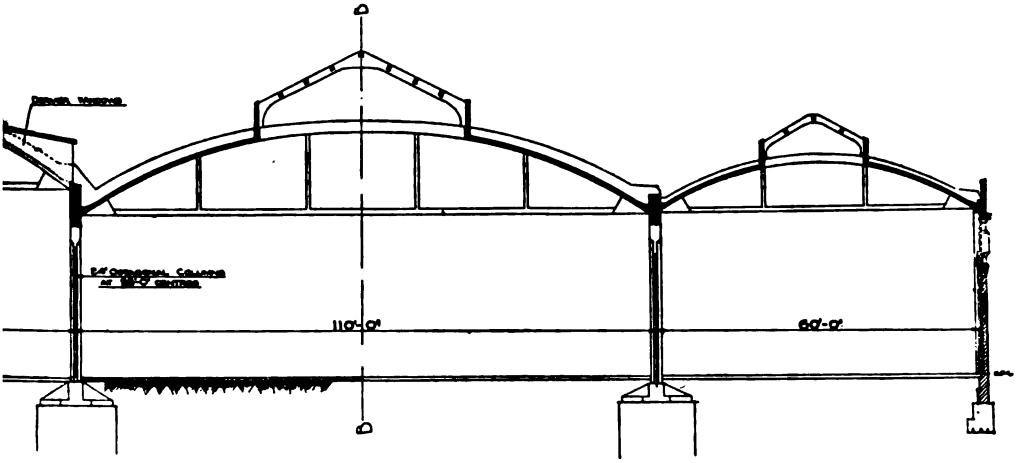
In addition, the calculation of stresses in the various parts of the work had to comply with the regulations and requirements of the Dean of Guild Court. This authority, under the technical direction of the Master of Works and City Engineer, acts in a similar capacity to the Building Department of the L.C.C., and the regulations imposed by it, although not so exacting in detail as is the case with the existing L.C.C. Regulations, are sufficiently so to ensure adequate protection of the public interests it represents.

Fig. 3, a cross section of the main hall, illustrates the type of roof employed. Each span comprises a number of arch vault slabs and glazing. The columns are arranged in the longitudinal direction at every third truss, i.e. at 55-ft. centres. The maximum calculated load coming upon each of the main internal columns is 406 tons, while the actual load realised from the dead weight carried is 296 tons.

The foundations of these main columns at 55-ft. centres required special care and treatment. The foundations along Blantyre Street rest on natural stone formation. The foundation of the other pillars had to be taken down to a low level for security, as the stone rapidly gives place to forced material which, along the Bunhouse Road frontage, reaches to a considerable depth.

The main roof trusses are composed of arch ribs, ties, and vertical hangers or suspenders. The ribs are true arch members, the thrust being taken by the ties connecting the springings. In designing these members, several important points arose. First, it was necessary carefully to consider the stresses resulting from what are usually known as "secondary effects." In spans of this size, however, these effects are certainly of first importance. These trusses are bowstring girders in the proper sense, the elastic extension of the "string" or tie inducing deformation of the "bow" or arch rib. There is further deformation of the arch rib caused by its elastic shortening when compressed, and also due to the shrinkage of the concrete during hardening. All these effects are cumulative, and the stresses they produce are permanent throughout the life of the structure. They are therefore of vital importance in the design of such work.

There is no difficulty as regards the



V: CROSS SECTION THROUGH MAIN HALL.

vertical loading to be carried, since the superload can reasonably be assumed to be evenly distributed and the axis of the arch therefore made to coincide exactly with the line of pressure due to vertical loading. This was done in the case of this roof, and the curve of the soffit, although not of the usual kind, is not noticeable, owing to the elimination of the underside of the transverse projecting members.

The second point of importance in such construction is the connection of the arch ribs and ties and columns at springing level. Over a relatively small area of material the entire horizontal component of the thrust from a rib, amounting in this case to about 86 tons, has to be transmitted to the tie, while the vertical component of the thrust must be brought on to the columns without any eccentricity, which, if permitted, would have the effect of introducing intense and unknown stresses at the heads of the columns.

The tension in the ties is considered to be taken wholly by the steel reinforcement. This, however, does not mean that concrete embedding this reinforcement acts only as a protective cover. On the contrary, without the concrete the tie could not function, since it was not possible practically to procure rods of sufficient length to span from end to end without a break.

With a tension member of such a relatively small cross section (9 in. by 13½ in.) containing many rods of larger diameter, the old method of lapping the rods and terminating them with hooks is not practicable or even desirable technically. Instead, a system of butt joints for the reinforcement has been arranged in such a way that at any cross section the requisite efficient sectional area of steel is present to keep the tensile stress in the member within the prescribed limits. The main spans of 110 ft. are believed to be the largest of their type yet attempted.

Special care is required during construction to obviate any undue distortion of the curved vault slab, which might result in unsightly, although non-structural, hair cracks appearing. It is obviously impracticable to release the whole of the staging simultaneously, and in carrying this out piecemeal certain roof trusses are in their final condition (i.e. deformed under load) whilst others remain propped, causing longitudinal bending in the concrete construction between the trusses in question.

In designing the external wall columns allowance had to be made for the lateral movements taking place at their heads as a result of the roof ties extending under stress. To facilitate the contractor's operations, the centre 110-ft. span was omitted until the spans on each side were concreted. The total continuous length

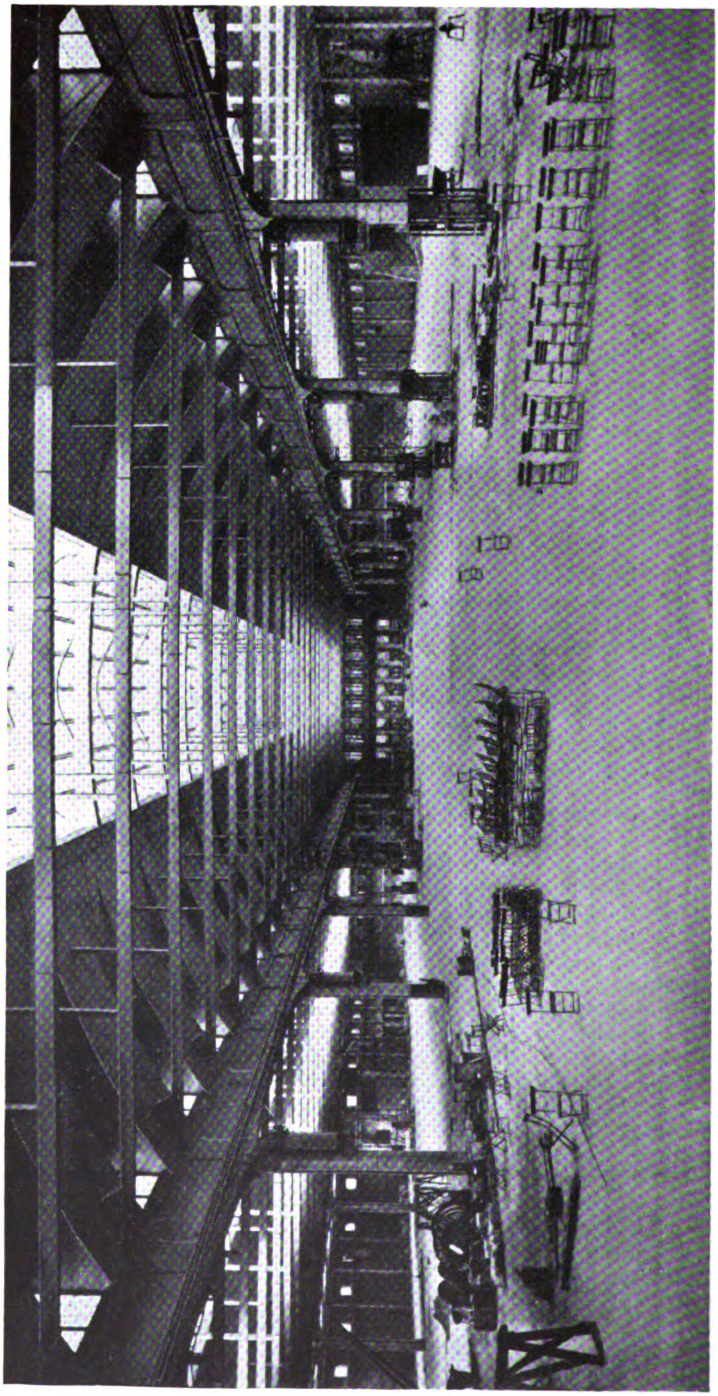


Fig. 4.—New Kelvin Hall, Glasgow : Interior View.

Fig. 4. New Kelvin Hall, Glasgow: Interior View.

of the tie beams is 390 ft., and when subjected to the calculated maximum stress the possible lateral displacement at their ends was estimated to be about 1·2 in. The external columns were therefore designed to accommodate such a movement, although in fact such a displacement was not realised owing to the absence of the presumed superimposed loading. Also, of course, the rigidity of the intermediate supporting columns tends to lessen the calculated movement. In addition to the arrangement made for transverse movement, provision has also been made for expansion and contraction in the longitudinal direction of the roof.

As a result of these precautions no cracks of any kind have occurred in any part of this very large area of roof, which is further proof of the suitability of reinforced concrete for work of this nature. The maintenance costs of the Hall will be negligible, while the initial cost of the work compares favourably with any other form of construction.

The mixture of concrete used was 1 : 1½ : 3 for the whole of the reinforced concrete work, except the interior octagonal columns which were constructed with a richer mix.

Upon the completion of concreting and the removal of the staging and shuttering, the interior visible concrete surfaces were rubbed down and washed with a mixture of white cement and cream-coloured sand. The effect of this is to make the surfaces even in texture and pleasing in colour. No rendering in the form of plaster was permitted.

Three cupolas, 40 ft. wide and extending practically the whole length of the Hall, together with a fourth cupola over the 60 ft. span, give a remarkably uniform distribution of daylight over the whole area. Adequate means of natural ventilation is provided by the opening side-lights of these cupolas, the dormer windows in the centre 110-ft. span, and the windows in the external walls. In addition, the fans which form part of the heating batteries can be employed to cool the atmosphere.

The concrete roof is covered with natural rock asphalt. The floors are of concrete with a covering of natural rock asphalt for two-thirds of the area and tar macadam for the remaining third.

The Corporation, in their endeavour to make this hall as up-to-date as possible, have provided all the services it is anticipated will be required by stallholders. An ample number of outlets connected to the drainage system are placed in the floor to give facilities for taking away waste water. The other services are supported along the external walls and valley beams, where connections can easily be made to the gas and water pipes and the electrical installation. The heating is by steam.

The public gain access to the Exhibitors' Hall from the piazza, which is 90 ft. long by 25 ft. wide, and egress to Blantyre Street, Old Dumbarton Road, and Bunhouse Road.

The building was commenced in March, 1926, and opened by H.M. the King on 12 July, 1927. This period of construction included the general strike of last year, and other local industrial disturbances, all of which tended to delay the progress of the work.

The general contractors were Messrs. John Train & Co., Ltd.; Messrs. Edmiston Brown & Co., Ltd., were the contractors for the electrical installation and automatic telephone system; Messrs. Jas. Combe & Son, Ltd., for the heating work; Associated Fire Alarms, Ltd., for the automatic fire-alarm system; and Messrs. Doulton & Co., Ltd., for the sanitary fittings.

Messrs. Carreras' New Factory.

MESSRS. CONCRETE AGGREGATES, LTD., inform us that they were responsible for the removal and disposal of the material excavated from the site for Messrs. Carreras' new factory at Mornington Crescent, which was described in our last number. About 70,000 yds. were excavated, and on one occasion as much as 953 cu. yds. were removed in one day of twelve hours. Specially-built lorries were used for the work. Messrs. Concrete Aggregates, Ltd., also inform us that they are also supplying the whole of the aggregate and sand required for the work, and deliveries have been made of over 300 cu. yds. in one day.

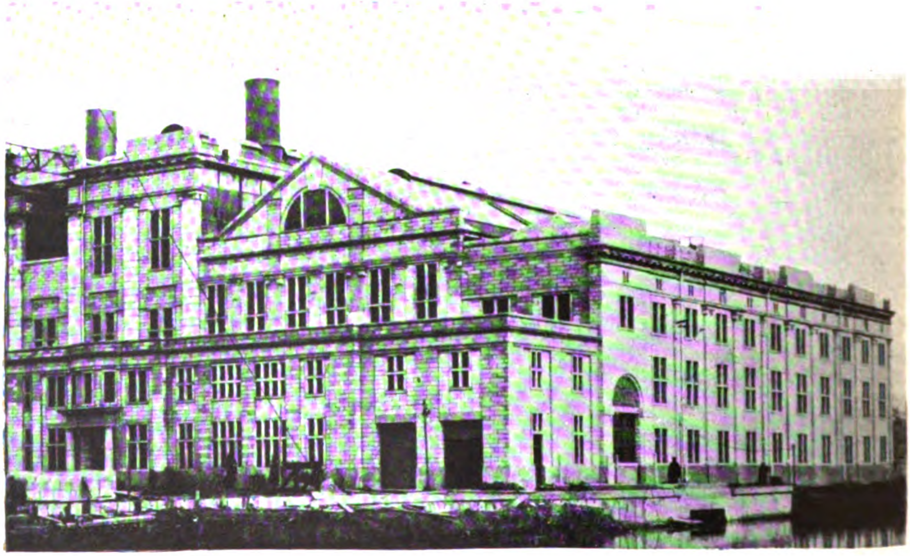
Norwich Power Station.

An example of the architectural possibilities of pre-cast concrete blocks has just been completed in the new super power station which has been constructed by the Norwich Corporation at Thorpe. The main building work has been carried out by direct labour, under the supervision of the City Engineers; first by Mr. A. E. Collins, M.Inst.C.E., and subsequently by Mr. J. S. Bullough, A.M.Inst.C.E. The whole of the walling of this building, an illustration of which appears on this page, is in concrete blocks, either 36 in. by 9 in. by 9 in., or 36 in. by 4½ in. by 9 in. The exterior walls are hollow. A special feature is that the outer faces of the whole of the blocks for the external elevations are of local ballast and cement faced with china clay micaceous quartz sand and white cement.

There has been no attempt to introduce a surface pattern, but a matt surface has been obtained by spraying with water when the cement was in the right condition for roughening the surface by this means to the desired extent. Frequently the spraying was done accidentally by rain storms, with the result that many variations in texture have been produced. The micaceous quartz sand was obtained from china clay works in Cornwall.

The adoption of concrete blocks solved a problem which was becoming increasingly acute in the Norwich district. Brick supplies had become so difficult that it was doubtful whether a sufficient supply would have been forthcoming for such a purpose. Moreover, the blocks have all the appearance of finely-dressed white granite, presenting a much more effective appearance than if the building had been erected in bricks. The architectural treatment adopted is very simple, consisting of bold pilasters and big panels with wide cornices. All the details are on a large scale, as the building is generally seen from a distance of at least 100 yards. Some of the walls are 50 ft. or more in height. The total cost of the structure was £93,839.

All the blocks were made on the job by direct labour with a "Winget" No. 1 pressure machine. None of the men operating the machines had any experience of this work before, but they picked it up quickly and soon reached a satisfactory regular output.



Pre-Cast Concrete Block Elevations of Norwich Power Station.

Floor and Roof Slabs.

By **LESLIE TURNER, B.Sc., A.M.Inst.C.E.**

Loading and Supporting of Slabs.

THE following particulars relate to floor or roof slabs capable of carrying a superload of 1 cwt. per square foot exclusive of the dead load of the slab itself, and distributed if required over the whole area of the slab. This superload is suitable for most ordinary purposes such as for domestic buildings, offices, factories, etc., housing no heavy machinery; but it would not suffice for ballrooms, drill halls, book stores, warehouse floors carrying heavy merchandise, or for a floor subject to severe vibration or impact. Such floors as these must be designed individually for loads from twice to ten times the amount stated.

In addition to the superload it is often required that walls or partitions be built above the slab to form rooms and compartments, and care must be taken that these are supported immediately beneath the slab by walls of equal or greater thickness, by joists, beams or other adequate support. While it is possible for slabs of smaller span to carry light breeze concrete plastered partitions, it must not be forgotten that these weigh about 180 lbs. per foot run when 8 ft. high, which requires that the floor should not be fully loaded to 1 cwt. per square foot close to the wall.

It will be appreciated therefore that a 4½-in. wall, plastered both sides, which brings over 400 lbs. per foot run of wall on to the slab, cannot be built indiscriminately on slabs unless both these and their supports have been designed to take them. Where 4½-in. or thicker walls are necessary these must be built over the slab supports; or if not, special beams must be inserted underneath.

It is not good practice to support floor slabs on 4½-in. brick walls, particularly walls in lime mortar, unless they are of very small span; a 9-in. wall should be considered the minimum. Where a slab passes over a 4½-in. partition a space of ½ in. should be left between the underside of the slab and the top of the wall; this space may be plastered up after the slab has been struck. If this is not done there will be danger of a crack forming on the upper surface of the floor following the line of the partition below.

Apart from walls, slabs may be carried on concrete beams with which they are incorporated or on rolled steel joists. The former will be dealt with later, but with regard to the latter there are two alternative methods:

(1) with the slab passing over the top flange;

(2) with the top flange of the rolled steel joists raised to within 2 in. of the upper surface of the slab.

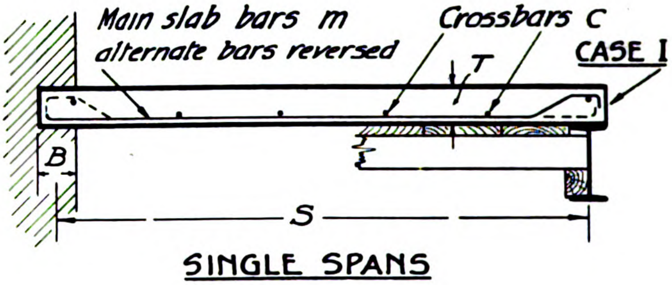


Fig. 1.

Case (1) makes the simpler job if there is no objection to the naked joist showing beneath, as illustrated on the right-hand side of *Fig.* 1. In continuous slabs the reinforcement, in this case, can pass freely over the joist.

Case (2) allows a few inches of headroom to be saved but requires haunching or the encasing of the joist in concrete. This is shown in *Fig.* 2, and if the casing is to envelop the joist completely a light mesh should be placed in the concrete around the lower flange. This method enables the cranked bars in the top of the slab to pass over the upper flange to gain the necessary continuity to transmit the tensional stresses, but necessitates the shortening of the lower bars, the ends of which must abut the web of the joist. The shuttering is more complicated and care should be exercised to see that the haunching is rammed solid, particularly under the upper flange, to transmit the compression through the web.

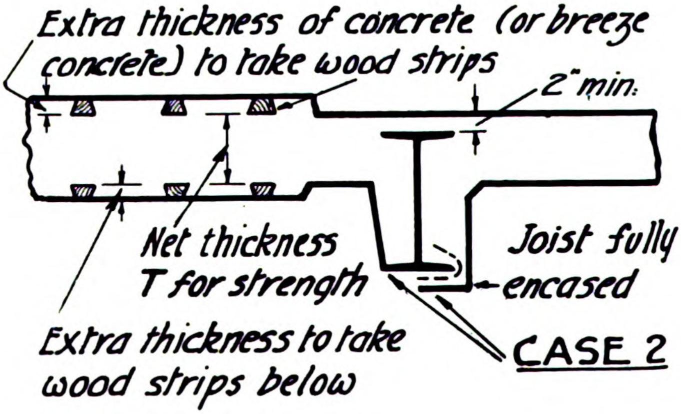

Extra thickness of concrete (or breeze concrete) to take wood strips
2" min.
Net thickness T for strength
Joist fully encased
Extra thickness to take wood strips below
CASE 2

Fig. 2.

Formwork.

It is essential that the boarding should be rigid and amply strong to carry the wet concrete and any incidental load likely to come on or across the floor. The sheathing used is usually 1 in. or 1¼ in. carried on 4 in. by 2 in. or 6 in. by 2 in. joists at intervals up to 2 ft. or 2 ft. 6 in. according to the circumstances. In the case of a floor on concrete beams these joists may be supported at their ends by the side moulds of the beam, although additional centre supports may also be necessary according to span.

Where the floor rests on steel beams the joists may be supported on chocks and wedges resting on the lower flange, as shown in *Fig.* 1. If the beam is encased the boarding or joists will have to be supported on props, securely braced from below, unless special iron clips or bolts are devised to fit on the lower flange to hold the formwork temporarily and allow of its final removal.

Using ordinary Portland cement the boarding forming the soffit to floor slabs must not be struck until seven days have elapsed after pouring, while the floor should not be fully loaded for five or six weeks. Nor should a new concrete floor be used to support the props from a higher one unless it is mature and at the same time is structurally capable of taking the load without overstressing. If a test load is called for, this must not exceed 1½ cwts. per square foot, gradually applied and removed not earlier than eight weeks after the last portion was poured.

A plank walk raised clear of the reinforcement must be provided if the concrete is conveyed in barrows.

Placing of Reinforcement.

The centre lines of the bars should be clearly marked or chalked on the upper surface of the boarding before the reinforcement is placed. This will save much time in the end. If the same centres continue for some distance it is worth while making a template by notching the lower edge of a board at the correct intervals, through which the bars can pass and become correctly placed automatically.

Crossbars are placed above the main bars in the bottom, and below in the top of a slab. The whole mesh must then be firmly wired at the crossings to resist displacement during concreting. Great care must be exercised that the cranked-up bars in the top of the slab do not roll over and fall into the centre or bottom. It is essential, particularly in continuous slabs, that the cover above the top bars be equal to that below the lower bars, namely ½ in. The lower cover can be maintained conveniently by short lengths of ½ in. bar placed immediately on the boarding and withdrawn as concreting proceeds. They must, of course, be pulled along as soon as the concrete has been tamped

1·2·4 CONCRETE — SINGLE SPAN SLABS — LIVE LOAD 112 lbs. PER SQ. FT.

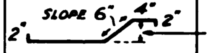
SPAN S	END BEARING B	SLAB THICKNESS T	MAIN BARS m		CROSS BARS c	QUANTITIES PER SQ. YARD OF FLOOR				
					AT NOT MORE THAN	CONCRETE	REINFORCEMENT			
	IN.	IN.	DIAM: IN.	CTRS: IN.	12 IN CENTRES	CU: FT:	LBS.	LGTH. OF MAIN BARS	BENT	CRANK IN.
3'-0" & UNDER	3	4	¼	7	4 - 5/16	3	5·3	S+B+3"		3
3'-6" " "	3	4	¼	6	4 - 5/16	3	5·7	"	" " "	3
4'-0" " "	4½	4	¼	5½	5 - 5/16	3	6·2	"	" " "	3
4'-6" " "	4½	4	5/16	6	5 - 5/16	3	7·3	"	" " "	3
5'-0" " "	4½	4	3/8	8	6 - 5/16	3	8·1	"	" " "	3
6'-0" " "	4½	4	3/8	6	7 - 5/16	3	9·1	"	" " "	3
7'-0" " "	6	4	3/8	5	8 - 5/16	3	11·6	"	" " "	3
8'-0" " "	6	4½	3/8	4½	9 - 5/16	3·375	12·8	"	" SLOPE 7" "	3½
9'-0" " "	6	5	½	7	11 - 5/16	3·75	13·2	"	" SLOPE 8" "	4
10'-0 " "	6	6	½	6	11 - 3/8	4·5	17·0	"	" SLOPE 10" "	5

Table B.—Single Span Slabs.

beneath the main bars and can support it, and not left until the concrete has commenced to set, when removal would injure the slab. The bars in the top can be supported on small concrete blocks of the required size to hold the reinforcement at its proper level. Wood blocks should not be used on account of the danger of their being accidentally concreted in. This risk is minimised by the use of concrete blocks, metal chairs or spacers.

Concreting.

Commencing at one support, a definite area of slab should be enclosed by vertical boards of the exact depth of the slab and temporarily fixed to act as runners for the screeding board and to form a rigid side against which the concrete can be rammed. It may be necessary to notch these to allow bars to pass through. The concrete must be poured to its full thickness in one operation and must be thoroughly pushed and tamped under and around the bars. The final spading should leave the upper surface a little on the high side so that the screeding board, when worked slowly forward with a to-and-fro movement, brings the surface to true level against a slight pressure of wet concrete. After that neither the concrete nor the projecting bars should on any account be disturbed.

Where it is not possible to finish the whole slab at one pouring the joint should be chosen along the centre of the slab, midway between two supports. On no account should it be made over or near the main supports of a slab. A temporary board should be fixed to finish against, and the joint washed and grouted before continuing next day.

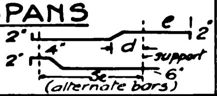
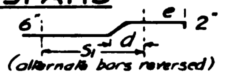
Finishes to Slabs.

On the underside it is sometimes required that " grounds " or tapered strips of wood be concreted in to carry ceilings, etc. In these cases additional thickness must be allowed to take the strips without encroaching on the normal cover under the bars as shown in *Fig.* 2.

The same applies to boarded finishes to the upper surface, although generally the extra thickness is executed in breeze concrete. To place wood strips in the net thicknesses of slab given later, either in the top or bottom, may reduce the strength by more than 50 per cent.

Granolithic may be laid as soon as the slab has taken its final set, providing every care is taken not to vibrate or injure the green concrete. Scoring and fluting the surface may be carefully undertaken while the surface is soft, by the free use of planks and walking boards. For the production of hard and wear-resisting surfaces there are other preparations which are applied either in liquid form, such as silicate of soda, or as a finishing coat.

1·2·4 CONCRETE — **CONTINUOUS SPAN SLABS** — LIVE LOAD 112 lbs. PER SQ. FT.

SPAN S	SLAB THICKNESS T IN.	END SPANS MAIN BARS m						INNER SPANS MAIN BARS m					
		DIAM. IN.	CTRS. IN.	WT. PER SQ. YARD	d	e IN.	LENGTHS	DIAM. IN.	CTRS. IN.	WT. PER SQ. YARD	d	e IN.	LENGTH
3'-0" & UNDER	4	1/4	9	5·1	Se/5	12	Se + 10" & Se + 1'-7"	1/4	9	5·7	S1/5	12	S1 + 1'-9"
3'-6" " "	4	1/4	9	5·1	"	12	" + 10" " + 1'-7"	1/4	9	5·6	"	12	" + 1'-9"
4'-0" " "	4	1/4	9	5·1	"	12	" + 10" " + 1'-7"	1/4	9	5·4	"	12	" + 1'-9"
4'-6" " "	4	1/4	6½	6·1	"	15	" + 10" " + 1'-10"	1/4	7½	6·0	"	15	" + 2'-1"
5'-0" " "	4	1/4	5½	6·7	"	15	" + 10" " + 1'-10"	1/4	6½	6·5	"	15	" + 2'-0"
6'-0" " "	4	5/16	6	8·3	"	18	" + 10" " + 2'-1"	5/16	7	8·2	"	18	" + 2'-3"
7'-0" " "	4	3/8	6	10·7	"	21	" + 10" " + 2'-4"	3/8	7	10·4	"	21	" + 2'-6"
8'-0" " "	4	7/16	6½	12·7	"	24	" + 10" " + 2'-7"	7/16	8	11·8	"	24	" + 2'-9"
9'-0" " "	4½	7/16	6	13·7	"	27	" + 10" " + 2'-10"	7/16	7	12·7	"	27	" + 3'-0"
10'-0" " "	5	1/2	6½	16·0	"	30	" + 10" " + 3'-1"	1/2	7½	15·1	"	30	" + 3'-3"

END BEARING B. QUANTITIES OF CONCRETE, CRANK & SLOPE MEASUREMENT OF BAR SAME AS EQUIVALENT SLAB THICKNESS IN TABLE B

CROSSBARS C. ONE LESS THAN FOR EQUIVALENT SPANS IN TABLE B — OR 5/16" BARS AT NOT LESS THAN 12" C/C

Table C.—Continuous Span Slabs.

Single-Span Slabs.

Single-span slabs may be defined as slabs which span between and rest on two supports only. The supports referred to are those closest together between which the main slab bars run. There will usually be end supports—such as the two end walls of a long corridor—but these are of no value in supporting the bulk of the slab. The supports may be brick walls, concrete beams, steel joists or a combination of any, as shown in *Fig.* 1. The particulars for spans up to 10 ft. are given in *Table* B. The span " S " refers to the distance, centre to centre, of the supports ; " B " gives the minimum end bearing on walls in inches ; " T " gives the thickness of the slab in inches ; column " m " gives the diameters and centres of main bars in inches, and column " c " the number and diameter of crossbars. The remainder of the table gives the volume in cubic feet of the concrete and the weight of reinforcement required per square yard of slab, together with particulars of the length and bending of the bars. The depth of the crank is measured outside to outside of bar, leaving ½ in. cover of concrete top and bottom when in place.

The following example will illustrate its use : Required a slab to span between a wall and joist 4 ft. 6 in. clear, as shown in *Fig.* 1. If breadth of top flange is 4 in., span *S* becomes 4 ft. 6 in. + 2 in. + 2½ in. = 4 ft. 10½ in.

Referring to *Table* B, and reading from line " 5 ft. and under," we find we require a 4-in. slab with ⅜ in. main bars at 8 in. centres and six ⁵⁄₁₆ in. crossbars. If there are 20 sq. yds. of slab (note that this area must include that let into the wall in the case of a chase left in wall) then 60 cu. ft. of concrete and 162 lbs. of steel are required. Each main bar will be 5 ft. 5½ in. long, cranked 3 in. to a 6-in. slope 4 in. from one end, and both ends bent up or down 2 in. Alternate bars will be reversed so that a straight end runs on to a support between two cranked ends, throughout the length of the slab. The crossbars should extend the length of the slab, but if it is necessary to splice them, the laps must be at least 18 in. long, well wired, and staggered on plan.

Continuous-Span Slabs.

As their name implies, continuous-span slabs carry over three or more supports, the slab being monolithic or continuous over the support. This continuity has two effects : (1) it results in an economy of material, (2) it introduces certain conditions which it is important to appreciate because they are not so common or so vital in other types of building construction.

These conditions are the reverse moments at supports, causing

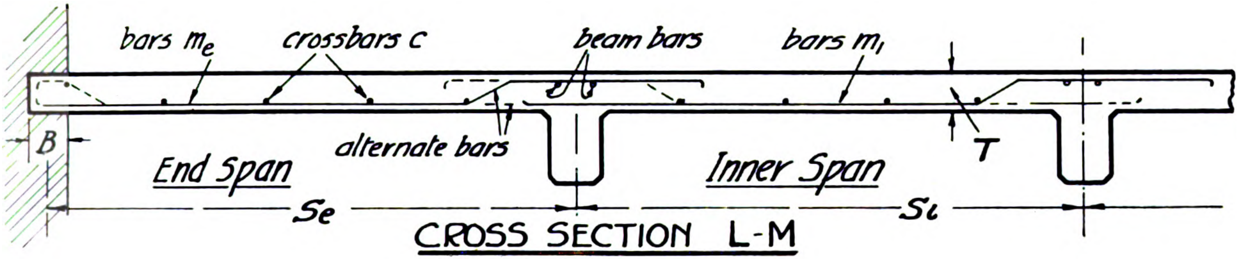

bars m_e
crossbars c
beam bars
bars m_1
alternate bars
T
B
End Span
Inner Span
Se
Si
CROSS SECTION L-M

Fig. 3.

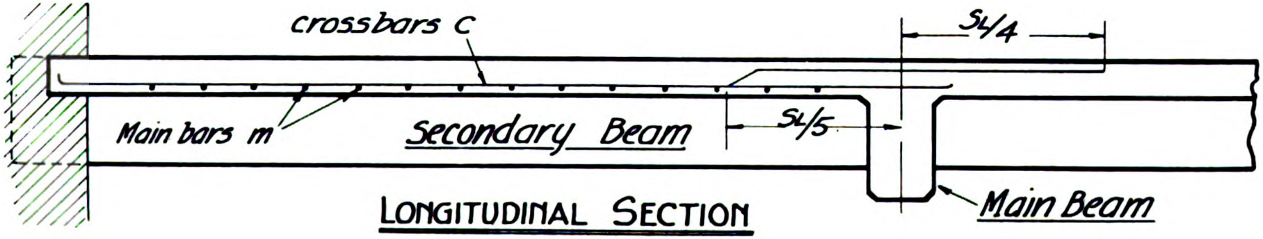

crossbars C
Si/4
Si/5
Main bars m
Secondary Beam
Main Beam
LONGITUDINAL SECTION

Fig. 4.

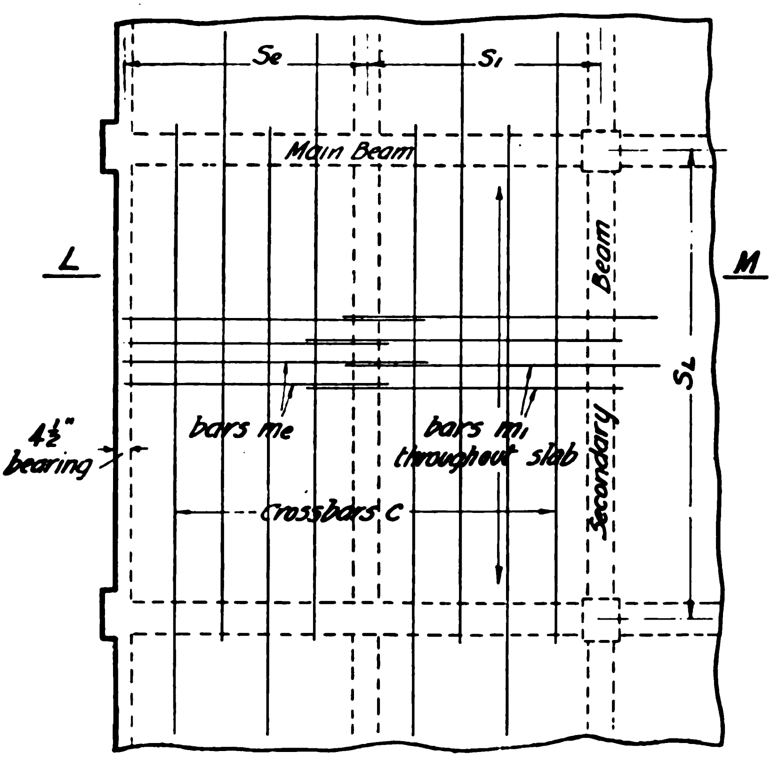


Fig. 5.—Plan.

tensional stresses in the top surfaces of slabs for some distance on each side of a support. These stresses, being taken only by the steel, call for the accurate placing of the reinforcement bent up over the supports. A load placed on one span always affects the spans on each side through this continuity, so that a large span continuous with a much smaller one will cause effects too complicated to explain here.

In the particulars that follow, therefore, it is assumed that the spans are of approximately the same order, deviating to say not less than 75 per cent. or more than 30 per cent. from the standard adopted. This can usually be achieved by inserting more walls or beams below or by rearranging their intervals. For convenience when spacing supports the inner spans should be kept constant to some even amount of feet and inches, while the two end spans should be made less. Always avoid larger end spans.

Particulars and sizes are given in *Table* C, while *Figs.* 3, 4 and 5 illustrate the typical arrangement of bars. It will be noticed that the thickness of slab for any particular span is the same for end as for inner spans, but that the reinforcement is usually slightly heavier in the case of end spans.

In arriving at the lengths of the main bars (m),

Se = the length of end span,
Si = ,, ,, ,, inner ,,

as shown in *Fig.* 3, a section taken parallel to the main bars.

Note that the bars in the top run past the centre line of the secondary beam or joist by an amount "e" given in the Table, and that the crank turns up at a length "d" on the other side: this point should be marked on the boarding to facilitate placing. At their straight ends they must run 6 in. past the centre line of the support. The crossbars, where they run over main beams, joists, or walls are also dealt with similarly, as indicated in *Fig.* 4. Crossbars, however, lie on top of main bars in the bottom of slabs, but below main bars in the top of slabs.

Two types of bar are required as main reinforcement to end spans, the one alternating with the other. The cranked end resting on the end support is bent as for single-span bars given in *Table* B. Bars for inner spans are of one type but the cranked ends project alternately in opposite directions as indicated on the plan *Fig.* 5.

The bending and lengths are figured for slabs on concrete beams or passing wholly over the top flange of rolled steel joists. If the flange of the latter is raised to within 2 in. of the upper surface of the slab then the cranked-up bars will pass over freely; but their straight ends must be shortened so as to abut the web of the joist, which must be haunched or encased with concrete.

The weights of reinforcement given include for crossbars and laps and must be considered a minimum. For convenience the size of bars may be increased or their centres reduced, to maintain a standard size and spacing throughout a floor.

Example.—A floor slab is required to carry a maximum live load of 1 cwt. per square foot over concrete beams spaced at 5 ft. centres (*Si*) with an end bay span of 4 ft. 6 ins (*Se*) (equivalent clear end span 4 ft. 3½ in.).

From *Table* C the thickness of slab "T" is found to be 4 in. for inner and end spans. Also the reinforcement is similar, namely, ¼ in. diameter bars at 6½ in. centres. Had the end bay been 5 ft. span then the end span reinforcement would have been ¼ in. bars at 5½ in. centres. The length of the main bars would be 5 ft. 4 in. and 6 ft. 4 in. (an equal number of each to be supplied) for the end span and 7 ft. for the inner bays. Five $\frac{5}{16}$ in. crossbars are required in the end bays and four in the inner—note in the case of concrete beams the top bars of the beam take the place of a crossbar. With rolled steel joists extra crossbars would be required in these positions. The crossbars should be bent and placed as shown in *Figs.* 4 and 5.

Quantities.

For estimating purposes the quantities from *Tables* C and B will be found to be :

Concrete	3 cu. ft. per square yard of floor.
Reinforcement (end spans) .	6·1 lbs. „ „ „ „ „
„ (inner spans) .	6·5 lbs. „ „ „ „ „

Book Reviews.

"Civil Engineering Specifications and Quantities." By G. S. Coleman and G. M. Flood.

London: Longmans, Green & Co., Ltd. Price 10*s.* 6*d.* net.

According to the preface, this book was "originally designed to enable young civil engineers, and those in allied branches of engineering, to obtain a knowledge of the fundamental facts which have to be considered in preparing specifications and quantities." With such an aim clearness of expression and exactness are essential, since the class of reader to be catered for is not likely to be able to discern errors ; one could have hoped this important fact had been borne in mind by the authors.

Forty-nine pages are given to legal decisions concerning the duties of engineers and contractors. A chapter on conditions of contract follows.

The next five chapters deal with materials of construction and are marred by serious errors. Among these may be mentioned the following quoted statements by the authors :

(1) "Sand must be sharp," a requirement which is absolutely unnecessary.

(2) "A useful size [for sand] is from ⅛ in. to ¼ in., preferably smaller, and hence the sand should all pass a sieve of ⅛ in. square holes." One would like to know how ¼-in. grains can pass an ⅛-in. sieve.

(3) The test for organic matter in sand is stated to be made with "a 3 *per cent. saturated* solution of sodium hydroxide."

(4) "Limestone [as an aggregate] may be acted on by the water used in mixing, if *such comes from a peaty district.*" This is not a reason for rejecting limestone alone, as no aggregate will make good concrete when water containing humic acid is used.

(5) "The cements now used are Portland and Ciment Fondu." There is no mention of other special cements, and we fail to see why a trade name should be mentioned to cover a class of cement made by several manufacturers.

(6) "Concrete is normally composed of cement, sand and broken stone or brick." But Thames ballast, gravel and shingle are also used, and are infinitely preferable to broken brick, which is distinctly bad for reinforced work.

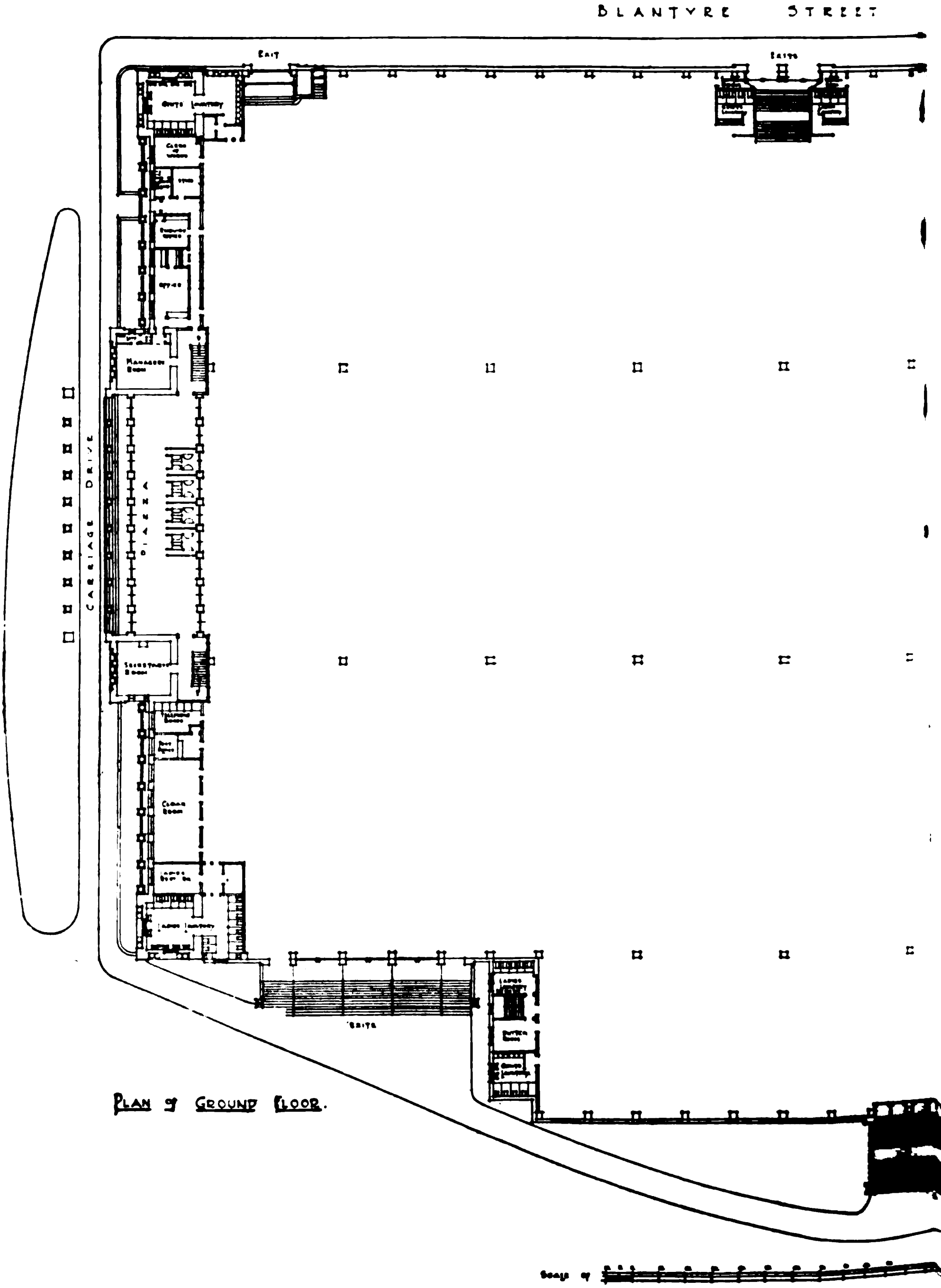
(7) "Concrete is *always* defined by the proportion by volume that the cement bears to the sand and broken material together." This statement is incorrect, and leads one to believe that the authors are not aware of the difference between a 1 : 2 : 4 and a 1 : 6 mix. Also, the cement is usually specified as so many lbs., or cwts., to *x* cubic feet of sand and *y* cubic feet of coarse aggregate.

No mention is made of modern methods of proportioning, fineness modulus, slump test, water-cement ratio, etc.

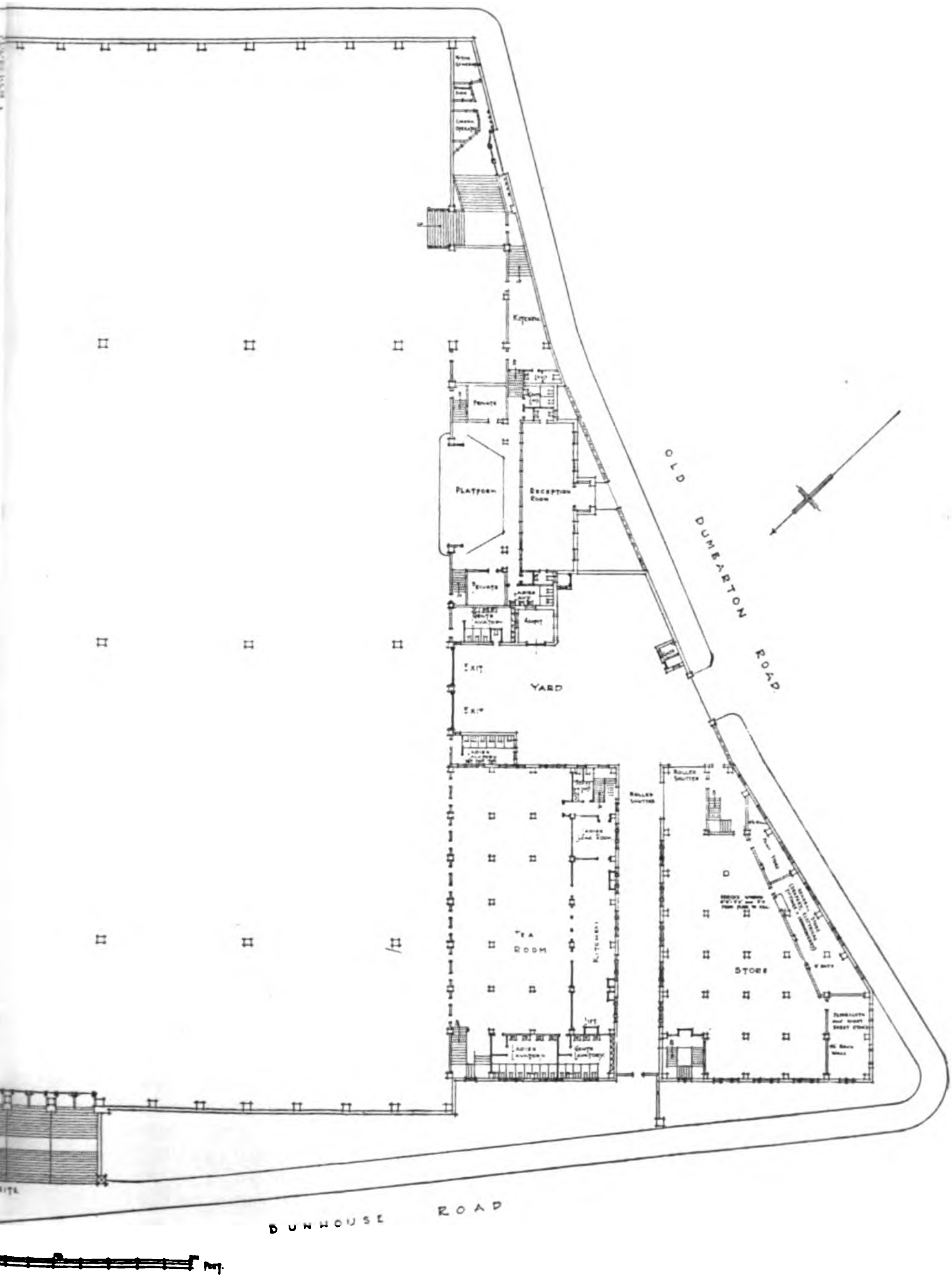
On page 96 the reader is informed that "iron oxide *is composed of* hæmatite and rust" !

On page 117, in connection with asphalte, we read that "to determine the ash a suitable quantity of the ash is slowly carbonized in an open platinum

(*Continued on page* 508).



GENERAL PLAN OF NEW KELVIN HAL



, GLASGOW. (*See p.* 489.)

(*Continued from page* 505.)

dish, and what is left is burned until all the carbon has been consumed." The authors alone can explain the meaning of this amazing sentence.

In the chapters on Workmanship no greater accuracy is shown than in the earlier parts of the book. On p. 145 it is recommended that concrete tunnels should have joint laths inserted as " such a procedure will prevent stresses due to setting." Laths may localise cracks, but they cannot prevent stresses.

The authors apparently have not a clear idea of the meaning of the term " stress," as on p. 148 they state that reinforcing bars must not be bent in such a way as to *overstress* the bars !

Few engineers will agree with the statement on p. 149 that " the side frames of columns should not be removed for at least seven days," particularly in view of the increasing use of rapid-hardening Portland cement.

The information on timber and concrete piles is inaccurate in many ways, and indicates a lack of practical knowledge of the subject. On p. 154 we read that " the increasing use of bauxite or artificial Portland cement, which *sets* very rapidly, will make the use of concrete piles more general." Bauxite cement is *not* artificial Portland, nor does it *set* rapidly.

The chapters on Quantities explain taking-off and abstracting in a manner which will be useful to the class of reader for whom the book is intended.

The book is well printed, but contains many mistakes in English.—W. S. G.

" Erdstatische Berechnungen." By W. Fellenius. 40 pp., 27 illus.

Berlin : Wilhelm Ernst & Sohn. Price : Paper, 4·20 mk.

PROFESSOR FELLENIUS, of the State Engineering College in Stockholm, is a well-known authority in Scandinavia on all matters dealing with earth pressure and allied problems, and this little book claims the attention of every engineer interested in the latest theories on the particular kind of statics that apply to the soil. Swedish scientists were the first to develop the theory of cylindrical planes of rupture, after the serious collapses of two important wharves in Gothenburg (in 1911 and 1916) had shown the usual assumptions accepted for the calculations to be unsafe and inadequate. But while the subject of cylindrical planes was dealt with by Petterson and Hultin so far back as 1916, it was treated under the usual assumption of friction alone acting along the surface of rupture. Professor Fellenius amplifies the investigation by assuming the presence of cohesion, either alone or in combination with friction, both in the case of plane and curved surfaces of rupture, and the methods of calculation developed in his book are of great importance for general statical problems such as the stability of dams, embankments, and retaining walls, particularly where the subsoil is of a weak or slippery nature.—R. N. S.

" The Orders of Architecture : Greek, Roman, and Italian." By the late R. Phené Spiers.

London : B. T. Batsford, Ltd. Price 12*s*. 6*d*. net.

PHENÉ SPIERS' " Orders of Architecture " is too well-known to the majority of our readers interested in the art of architecture. It is sufficient to say that a fifth edition has been found necessary, and that Messrs. Batsford have produced this in the excellent style one associates with all their publications. For the benefit of readers not acquainted with this work, we would say that it comprises 26 beautifully reproduced plates detailing the classic orders of architecture, in addition to numerous smaller drawings used to illustrate the author's discussion of the history and origin of the orders. These concise notes on the orders, together with the illustrations, constitute a standard book for students young and old, for which the author and publisher deserve their thanks.

" Simplified Roof Framing." By J. D. Wilson and S. O. Werner. 118 pp., 115 illus.

London : McGraw-Hill Publishing Co., Ltd. Price 7*s*.

THIS book appeals to students in building construction, and gives in concise language, illustrated with clear line drawings, the principles and practice of the construction of roof frames. Practically every type of roof is dealt with, and the fact that the book is of American origin does not detract from its value to the English reader. It is written so that no knowledge of mechanical drawing, geometry, or trigonometry is necessary to follow the authors' explanations.

Joints in Concrete Roads.

By **R. A. B. SMITH, A.M.Inst.C.E., A.C.G.I.**

EVEN as a railway line has to be constructed with joints at intervals to allow for the expansion and contraction of steel, so concrete, which has practically the same coefficient of expansion, has to be treated in the same way.

The coefficient of expansion of steel is 0·0000060 – 0·00000629. The coefficient of expansion of concrete is 0·0000050 – 0·0000065.

As has already been stated, when the conditions are such that the differences of temperature in the road surface are very small, continuous construction may be successfully adopted and cracks need not be expected to develop, or, if they do, at only very rare intervals.

There are many engineers who think that cracks are less trouble than joints, and they construct continuous slabs in exposed positions as well as in protected ones. Although a crack is not the objectionable feature structurally that might be expected, yet it is unsightly, and if it is possible to avoid them it is undoubtedly the duty of the engineer to do so. The reason why some engineers do not like joints is that in many roads constructed with joints insufficient care has been taken at these points, with the result that abrasion has been caused through difference of levels.

The probability is that the ganger employed has never constructed a concrete road before, and if he has constructed one he has never returned to see the result of his labours. In consequence, he never properly realises the importance of good work, and how quickly traffic discovers a weak spot. A bad joint may exist in a concrete floor for many years before showing signs of wear, but it only requires a few months of heavy traffic to show weak spots in a roadway.

In the opinion of the author a really intelligent man accustomed to the use of a float should be employed as a concrete road jointer, and he should be paid a skilled wage, so that a good joint is dependent only on a proper specification.

Joints for Continuous Construction.

(*A*) *Plain Butt Joint.*—The concrete may be finished up to a stunt head and work started the following morning straight away from the face thus obtained. By this method a road is obtained which is in fact a series of slabs though no actual expansion joints have been constructed. The joint is a plain butt joint and should remain good in unexposed positions.

(*B*) *Reinforced Joint.*—When the situation is on ground of an unreliable character a strengthening of this type of joint appears desirable, and then the engineer may carry the bottom reinforcement through the joint, and in addition introduce rods or mesh for not less than 18 in. on each side of the joint and passing through it (*Fig.* 1). The bottom timber (*b*) is placed so that the rods are at the top of the spaces provided, and the top timber (*c*) is then fixed to it either by vertical bolts or clamps. It is obviously not a difficult matter to remove this stunthead the next morning and continue the work. It has been noticed that in exposed positions this joint is not completely successful, as a transverse crack is sometimes formed at each end of the double reinforcement.

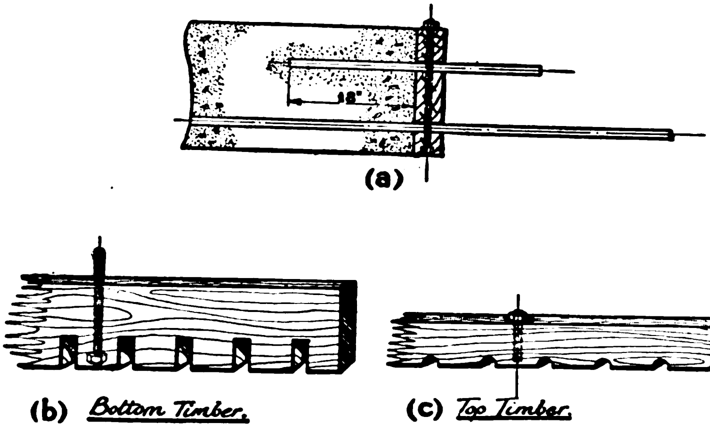


Fig. 1.—Method of Construction of Joint in Continuous Construction.

Joints for Alternate Bay Construction.

When double reinforcement is carried right through the joint then a system such as that described above may be adopted ; this is the method used by the Surrey County Council. In the concrete roads of the Middlesex County Council the reinforcement is stopped 2 in. short of the joint and a plain butt joint introduced ; this appears equally as successful.

Double reinforcement through the joint has not been proved necessary except under extreme conditions, i.e. a very bad sub-base. There are many instances of both these types of joint under various conditions, but so far neither has shown any advantage over the other. The opening formed between the panels when the concrete contracts is sometimes filled with bitumen, but it is questionable whether such treatment is necessary in this country where frosts and subsequent thaws are rarely, if ever, so severe as to cause an appreciable heaving of the sub-base, nor in the case of rain would that action be sufficiently increased to cause damage to the roadway by the amount of water which would find its way through the opening.

When certain double and treble meshes are employed the reinforcement should be carried through the joint in order to simplify construction, and for no other reason.

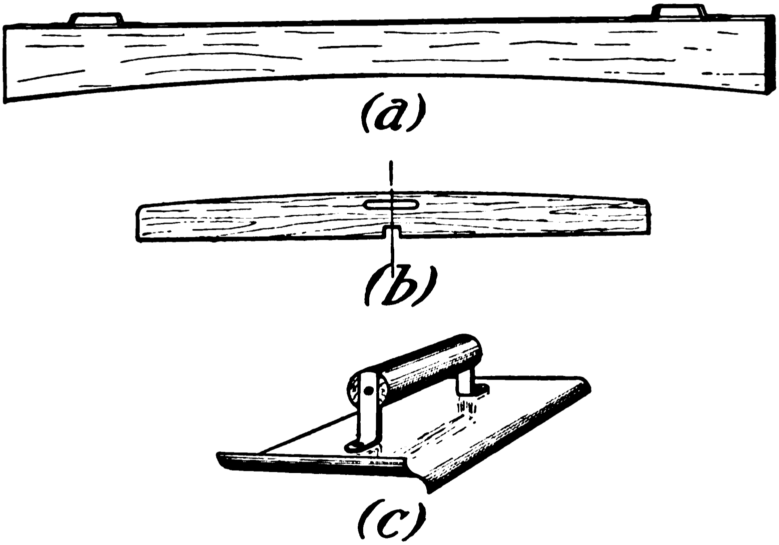


Fig. 2.—Tools for Expansion Joint Construction.

In more than one county an expansion joint has been introduced at every fourth bay or so, as for instance in Cumberland. This precaution would appear excessive had we not had that curious case of a burst in the Manchester area in a long level stretch of alternate bay construction, for which there has been no satisfactory explanation.

In Yorkshire a case has also occurred of a burst in alternate bay construction, but in this case the slabs were laid on a steep gradient and there is sufficient evidence to show that the slabs above had gradually pressed against those on the lower part of the gradient until the lower slabs had not sufficient room to breathe with the changes of temperature. Here we probably have a case where double reinforcement through the joints would help to keep the slabs in position.

Expansion Joints.

Expansion joints should not be regarded as a necessary evil, but as an integral part of the design. When it is appreciated what a useful function they perform, and great care is taken in their construction, it is not difficult to obtain a good result. The edges of an expansion joint must contain as high a percentage of aggregate as the remainder of the road, and to make them of sand and cement only is inviting failure. It must not be a "plaster" job. The operative requires a light straightedge notched in the centre (say, 18 in. long), an edging tool, and a wood float. He may also have a small quantity of granite, sand, and cement mixed to the proportions of 3 : 1½ : 1, the granite (or other good wearing quality aggregate) not exceeding ¼-in. size.

The usual method is to complete the concrete road to a cross form. This cross form may be of hardwood or steel, and should be the same thickness as the joint (*Fig 2a*). If of wood it should be well oiled, as it must be withdrawn within 24 hours. For the purpose of withdrawal it should have small handles at the top near each end.

Before the set is very far advanced the edging tool is run along each side of the cross form, turning the arrises of the concrete to about ¼-in. radius. These two edges must be perfectly true to each other, and if not absolutely correct they must be made so by removing or adding the necessary quantity of the mix. The notched straight-edge (*b*) will prove extremely useful. It may be necessary to throw over the road a light bridge of planks in order that the man may reach the work without walking on the wet concrete.

Immediately on the withdrawal of the cross form, the cavity is filled with a filler of bitumen until it is flush with the road surface. Fine granite or similar material as used for fine tarmac may be introduced into the top inch to stiffen it up and prevent the filler being removed by traffic.

Pre-Cast Joint Fillers.

The increased use of expansion joints has led several firms to put on the market a filler which is pre-cast. In order to stiffen it, fibre or some other material is used. These pre-cast fillers are supplied in various thicknesses and to any required depth. When pre-cast fillers are used, a cross form is fixed in place and the filler placed against it. In America the cross form is usually a thin steel plate with a ragged bottom edge. The concrete is then worked up to the filler and the second slab proceeded with. When about 2 ft. of the second slab is concreted the steel cross form is removed and the concrete rammed into the vacated space. The joint is then finished as described above.

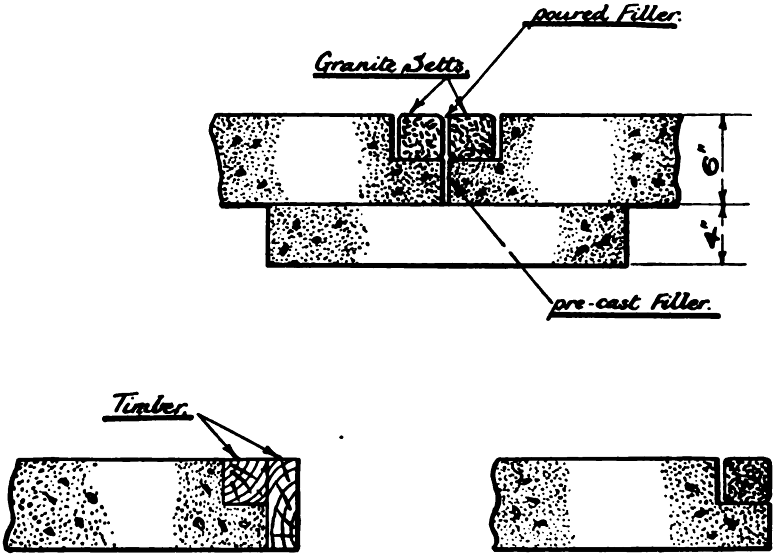


Fig. 3.—Expansion Joint finished with Granite Cubes.

Granite Cubes at Joints.

Joints do not give any further trouble where the traffic is rubber tyred, but in cases where steel-tyred traffic predominates, as in docks, any unevenness of the joint is immediately aggravated. To prevent this possibility, granite setts, 3 in. or 4 in. cubes, have been tried and are proving successful. If the concrete has a depth of 8 in. or more the setts can be laid in a recess left for them by attaching a piece of timber a full 3 in. or 4 in. square to the cross form as in *Fig.* 3. If the road is less than 8 in. thick, then a platform about 2 ft. wide and 4 in. thick is placed under the joint, as shown, and covered with paper to prevent adhesion. The setts are fixed with a sand-and-cement grout. In this case it simplifies construction if the slabs are laid alternately, as shown in *Fig.* 4. This gives the sett-layer easy access to his work, but of course it is not always feasible.

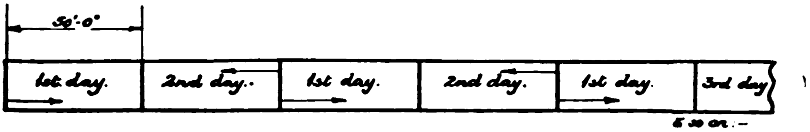


Fig. 4.—Method of Construction using Granite Cubes at the Joints.

Cork and Bitumen Filler.

Another interesting joint is that used at Herne Bay and other places (*Fig.* 5). Here the joint is 1 in. wide and the filler is a composition of cork and bitumen supplied by the Ruberoid Company. The filler compresses but does not flow, and on the contraction of the concrete released from pressure it expands again and keeps the joints tight. It is not advisable to make the gap less than an inch for this filler; nor must the designer extend the length of his slab by reason of this larger gap, as he will still have to contend with the friction between the concrete and the sub-base which restricts the length of the slabs to not more than 60 ft.

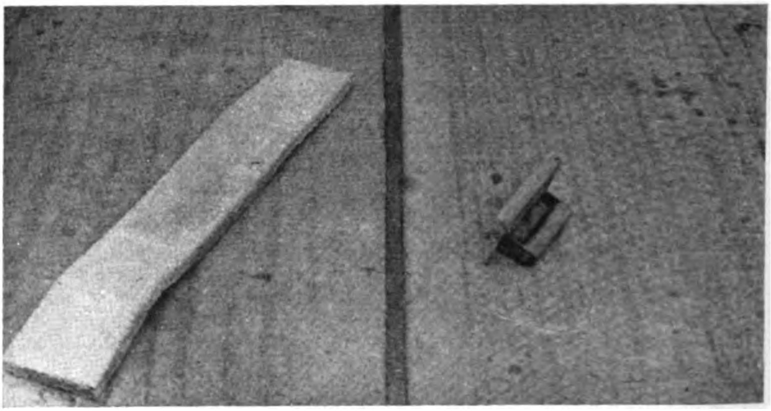


Fig. 5.—Cork and Bitumen Joint Filler at Herne Bay.

Distance Between Expansion Joints.

A formula, which it is admitted is open to criticism but nevertheless plays for safety, is as follows:—

$$L = \frac{s \times 12 \times d}{f \times w}$$

Where L = length of slab.

s = tensile strength of the concrete where failure takes place.

f = coefficient of friction of the slab on the sub-base.

Let $D = 8$ in. $f = 2s = 100$ at 14 days. $w = 100$ for 8 in. thickness.

$$\text{Then } L = \frac{100 \times 12 \times 8}{2 \times 100} = 48 \text{ ft.}$$

When steel reinforcement is used to help the concrete take the tensile strength, a slab of greater length may be possible, but at present there seems no evidence that 60 ft. can be safely exceeded.

Joints on Soft Ground.

On bad ground, such as peat bog, it seems thoroughly sound to strengthen the joints so that the moving load may be transmitted more gradually to the slab it is approaching. This is often done, as already mentioned, by double reinforcement through the joint, but an even better method is that adopted by the County Surveyor of Kildare (*Fig.* 6), which is as follows :—

At the expansion joints, 1 in. steel bars 3 ft. long were laid at 1 ft. centres on the neutral axis of the slab ; that is, there were seventeen bars at each joint laid 4½ in. from the surface between the top and lower reinforcement. The bars were first wrapped in tarred brown paper for half their length, and at the end a cap was inserted under the paper, which was then tied. These caps were about 3 in. long, cut from old bicycle frames, and half filled with bitumen. The object of the cap was to prevent the fresh concrete butting up against the end of the bar, which would thus counteract any expansion on the part of the concrete. The bitumen was stiff enough to prevent the caps being forced right down on the bar when the concrete was laid, but would not prevent any expansion taking place afterwards.

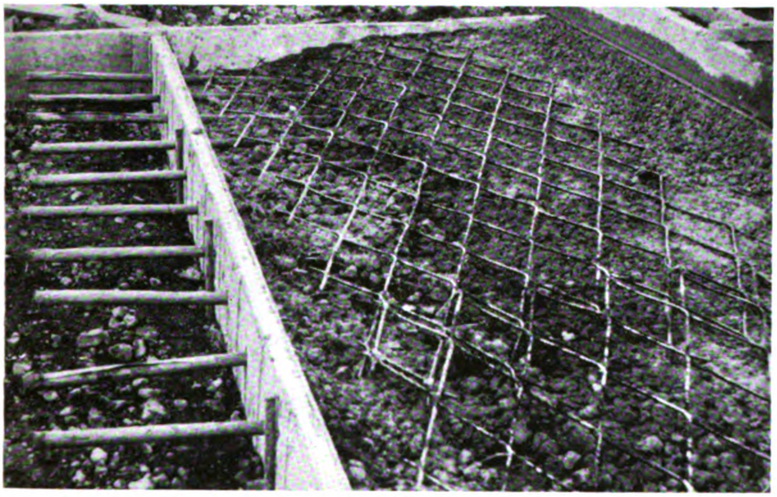


Fig. 6.—Method of Joint Construction for Soft Ground.

At the joint Callender's "Rezilia" was used, and this had holes cut in it at the correct level and distance for the bars, which were pushed through the holes until the paper was up against the " Rezilia." The timber stunthead also had holes cut in it at the correct intervals to allow the bars to protrude through.

When concreting at the joint, 4½ in. of concrete was first laid against the " Rezilia " and stunthead. Then the bars were pushed through the paper and outwards, and the rest of the concrete placed on top of the bars. The joint was then finished in the usual way.

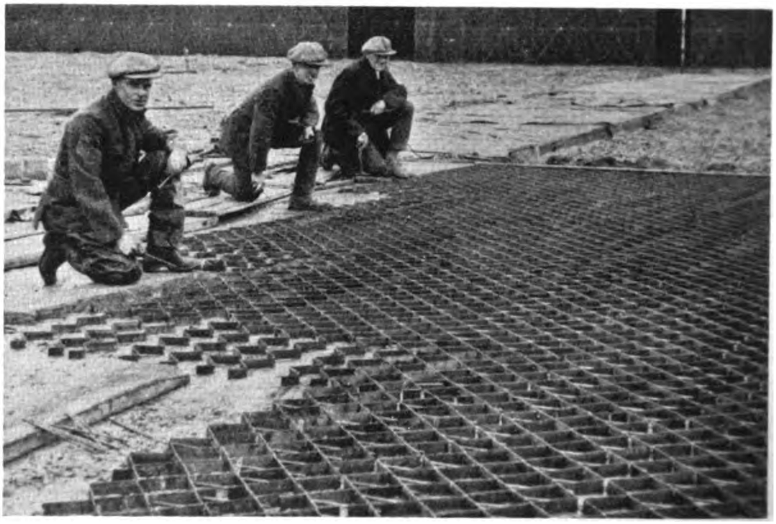


Fig. 7.—Steel Surface Mesh at Lydd Camp.

Patent Materials.

The use of certain patent productions has recently proved interesting. There is a material called " Betonac " which was tried at Sutton. The method employed was as follows :—" Betonac " steel concrete was let in to a depth of 2 in. on a width of 4 in. throughout the length of the joints. The metallic aggregate is in three grades, and equal quantities of the three grades are mixed with an equal volume of sand. Cement is added to the mixed aggregate (" Betonac " and sand) and the whole made into a stiff mortar. It is claimed that the fineness of the aggregate makes it possible to round off the arris to a very much smaller radius than is otherwise possible, in addition to which the high compressive strength of the aggregate minimises the danger of the surface breaking away.

A steel surface mesh has also been experimented with at Chelsea, Lydd, and other places (*Fig.* 7).

This consists of strips of steel bent to a zig-zag shape and let into the concrete at points where the wear is acute, as at the joints. The strips are placed adjacent to one another and keyed, and the surface is thus divided into a series of small squares, each bounded with steel strips on all four sides. The edges of the steel strips are finished flush with, and become part of, the finished surface.

(*To be continued.*)

The Cheam–Malden Concrete Road.

[This all-concrete road was laid for the Epsom Rural District Council in April this year, under the direction of Mr. T. E. Ware, Surveyor to the R.D.C. It is laid in two courses, a bottom course 7 in. thick and a top course 2 in. thick, reinforced with B.R.C. fabric.]

DATA FOR PRICING REINFORCED CONCRETE.*

MATERIALS DELIVERED 4 MILES FROM CHARING CROSS.

		s.	d.
Best Washed Sand	per yard	16	0
Clean Shingle, ¾ in. mesh	,,	14	0
,, ,, ½ in. mesh	,,	15	6
Thames ballast	,,	10	6
Broken brick (¾ in.)	,,	11	6
Best British Portland Cement (delivered London area)	per ton 58*s.* to	63	6
Rapid-Hardening Portland Cement	delivered London 10*s.* per ton extra		
"Super-Cement"	per ton 88*s.* to	93	0
"Lightning" Brand Aluminous Cement	,, 100*s.* to	105	6
Ciment Fondu	works f.o.r.	95	0

Boarding for Shuttering—

		Sawn. s.	Sawn. d.	Wrot. s.	Wrot. d.
1 in.	per square	23	6	27	6
1¼ in.	,,	29	6	33	6
1½ in.	,,	35	6	41	0

Sawn Timber for Struts and Supports—

3 in. by 4 in.	from £22 per standard
3 in. by 6 in. and 3 in. by 7 in.	,, £20 ,, ,,

Mild Steel Rods for Reinforcement—

		s.	d.
⅝ in. to 2½ in. Rounds	per cwt.	10	6
5/16 in. to ½ in. Rounds	,,	10	9
⅜ in. Rounds	,,	11	0
¼ in. Rounds	,,	12	0

Breeze Slabs per yd. super: 2 in., 1/11; 2½ in., 2/4; 3 in., 2/9; 4 in., 3/6.

MATERIAL AND LABOUR, INCLUDING 10 PER CENT. PROFIT.

(Based on Contracts up to £2,000.)

Portland Cement Concrete well mixed in proportion 1 : 2 : 4—

				s.	d.
Do.	do.	in foundation	per foot cube	1	11
Do.	do.	in columns	,, ,,	2	1
Do.	do.	in beams	,, ,,	2	3
Do.	do.	in floor slabs 4 in. thick	per yard super	6	0
Do.	do.	in floor slabs 5 in. thick	,, ,,	7	6
Do.	do.	in floor slabs 6 in. thick	,, ,,	9	0
Do.	do.	in floor slabs 7 in. thick	,, ,,	10	6
Do.	do.	in walls 6 in. thick	,, ,,	8	8

(Add for hoisting 3s. 6d. per yard cube above ground-floor level. Add for "Ferrocrete" 1s. 10d. per yard cube.)

Steel Reinforcement, including Cutting, Bending and putting into Position and securing with Stout Binding Wire—

		s.	d.
From ¼ in. to ⅜ in.	per cwt.	22	6
,, 5/16 in. to ½ in.	,,	21	6
,, ⅝ in. to 2½ in.	,,	20	6

EXTRA LABOUR TO BENDS in ¼-in. rods, ½*d.*; ⅜-in. rods, 1*d.*; ½-in. rods, 1¼*d.*; ⅝-in. rods, 1½*d.*; ¾-in. rods, 1¾*d.*; ⅞-in. rods, 2*d.*; 1-in. rods, 2¼*d.*; 1⅛-in. rods, 3*d.*; 1¼-in. rods, 3½*d.*; 1⅜-in. rods, 4½*d.*; 1½-in. rods, 6*d.* (per bend per cwt.).

EXTRA LABOUR TO HOOK BENDS: ¼ in., 1*d.*; ⅜ in., 2*d.*; ½ in., 2½*d.*; ⅝ in., 3*d.*; ¾ in., 3½*d.*; ⅞ in., 4*d.*; 1 in., 4½*d.*; 1¼ in., 6*d.*; 1½ in., 7*d.* (per bend per cwt.).

Shuttering—

		s.	d.
Shuttering and Supports for Concrete Walls (both sides measured)	per square	59	0
Centering to Soffits of Reinforced Concrete Floors and Strutting, average 10 ft. high	per square	55	0
Do. do. in small quantities	per ft. super	0	10
Shuttering and Supports to Stanchions for easy removal, average 18 in. by 18 in.	per ft. super	0	11½
Do. do. as last, in narrow widths	,, ,,	1	1½
Do. do. to sides and soffits of beams, average 9 in. by 12 in.	,, ,,	1	1½
Do. do. as last, in narrow widths	,, ,,	1	3½
Raking, cutting, and waste to shuttering	per ft. run	0	3
Labour, splay on ditto	,, ,,	0	2
Small angle fillets fixed to internal angles of shuttering to form chamfer	,, ,,	0	3

WAGES.—The rates of wages on which the above prices are based are:—Carpenters and joiners, 1/9½ per hour; Carpenters working on old shuttering, 1/10½; Labourers on building works, 1/4½; Men on mixers and hoists, 1/5½; Bar-benders, 1/5½.

[* This Data is specially compiled for *Concrete and Constructional Engineering*, and is strictly copyright.]

Prospective New Concrete Work.

BENTLEY.—*Bridge.*—The Ardwick-le-Street and the Bentley U.D.C.'s propose to erect a bridge in Bentley Moor Lane.

BILLINGHAM.—*Houses.*—The U.D.C. is seeking permission to borrow £3,000 for the purchase of land as a housing site.

BLAYDON.—*Houses.*—The U.D.C. has applied for sanction to erect 40 houses.

BRIDLINGTON.—*Sea Wall, etc.*—The T.C. has applied for sanction to borrow £54,000 for the construction of the south side sea wall and promenade.

BRIERLEY.—*Houses.*—The Brierley P.C. has recommended to Hemsworth R.D.C. to erect 100 houses.

BROXBRIDGE.—*Bridges.*—Plans have been prepared for the construction of bridges at Rock Corner and Lower Lane.

BUCKHAVEN.—*Concrete Road.*—The B.C. proposes to reconstruct Wellesley Road in reinforced concrete, at an estimated cost of £2,200.

CHIPPENHAM.—*Houses.*—The T.C. proposes to build 60 houses.

COLEFORD.—*Road.*—The Frome R.D.C. has applied for a grant towards the cost of constructing a road at Coleford. The cost is estimated at £10,000.

EVESHAM.—*Houses.*—The R.D.C. has applied for permission to borrow £37,400 for the erection of 84 houses.

GARVAGH.—*Road.*—The Coleraine R.D.C. proposes to construct a road in the Grove district, at an estimated cost of £2,000.

HANDBRIDGE.—*Houses.*—The Chester Corporation Housing Committee is considering a scheme for the construction of 33 houses at Handbridge.

ILKESTON.—*Houses.*—The T.C. has decided to erect 114 houses.

NEATH.—*Road.*—The Neath R.D.C. and Glamorgan C.C. are considering a proposal for the provision of a new Jersey Marine Road. The cost is estimated at £120,000.

JOHNSTONE.—*Houses.*—The T.C. proposes to erect 160 houses.

KINGSWOOD.—*Houses.*—The Bristol T.C. is recommended to apply for permission to borrow £10,580 for the erection of houses at Henshaw Road, Kingswood.

LITHERLAND.—*Houses.*—The Housing Committee is considering a proposal to build 100 houses at Litherland.

LLECHRYD.—*Bridge.*—A bridge is to be constructed at Llechryd for the Pembrokeshire C.C.

MACCLESFIELD.—*Houses.*—The T.C. proposes to build 100 houses.

MARGATE.—*Bridge.*—The Southern Railway Company propose to construct a bridge to replace the existing level crossing at Mutrix.

NEWQUAY.—*Houses.*—The U.D.C. has applied for permission to erect 40 houses in Lehenver Road.

POOLE.—*Road.*—A circular road is to be constructed on the Haven House site.

REDRUTH.—*Houses.*—The U.D.C. has submitted a scheme to the M.H. for the erection of 50 houses.

ROSS.—*Houses.*—The U.D.C. proposes to build 50 houses. The cost is estimated at £17,950.

RUSHDEN.—*Houses.*—The Surveyor has been instructed to prepare plans for the erection of 52 houses on the Irchester Road site.

ST. AUSTELL.—*Houses.*—The Housing Committee is considering a scheme for the construction of 110 houses.

SCARBOROUGH.—*Concrete Bridge.*—A reinforced concrete bridge is to be constructed over Peasholm Glen.

SEAHAM HARBOUR.—*Bridge.*—The U.D.C. is considering a scheme for the construction of a bridge in Strangford Road.

DUCKHAM'S
CONCRETE
MOULD
OIL

GOES FARTHEST
FUNCTIONS BEST

ALEXANDER DUCKHAM & Co., Ltd.
6 BROAD ST. PLACE, LONDON, E.C.2

Tenders Accepted.

Arbroath.—*Concrete Pipe Sewer.*—The T.C. has accepted the tender of Messrs. Ramsey & Gordon, Fergus Square, Arbroath, for the construction of about 484 lineal yds. of 3-ft. reinforced concrete pipe sewer.

Babingley (Norfolk). — *Concrete Bridge.*—The Norfolk C.C. has accepted the tender of Messrs. May, Gurney & Co., Ltd., Trowse, Norwich, at £910, for the construction of a reinforced concrete bridge at Babingley.

Caldbeck (Cumbd.).—*Concrete Bridges.*—The Cumberland C.C. has accepted the tender of Messrs. Cleghorn & Co., Bank Street, Carlisle, at £8,235, for the construction of two reinforced concrete bridges.

Chesham.—*Concrete Retaining Wall.*—The U.D.C. has accepted the tender of Messrs. Pinkerson & Co., at £1,263, for the construction of a reinforced concrete retaining wall 133 yds. long between Latimer Road and the River Chess. Other tenders submitted: R. E. Jenkins, £1,978; D. G. Somerville & Co., Ltd., £1,859; Simplex Concrete Piles, Ltd., £1,857; G. K. Waghorn, £1,703; L. J. Speight, Ltd., £1,524; Farmer & Co., £1,295; T. T. Broughton, £1,205; John Cochrane, £1,074.

Chipping Norton. — *Houses.* — The U.D.C. has accepted the tender of the Universal Housing Co., Rickmansworth, at £5,748, for the construction of 14 houses in Churchill Road.

Epsom.—*Concrete Road.*—The U.D.C. has accepted the tender of Messrs. Morrison (Roads), Ltd., Woking, at 10*s.* per super yard, for the construction of approximately 5,000 super yards of reinforced concrete carriageway on the housing site near Hook Road.

Horsforth.—*Concrete Road.*—The U.D.C. has accepted the tender of Mr. J. Parkin, The Banory, Horsforth, for the construction of 3,700 yds. of reinforced concrete carriageway.

Molesey. — *Concrete Houses.* — The U.D.C. has accepted the tender of the Triangular Construction Co., Ltd., for the construction of 8 concrete houses in Green Lane.

Naburn (Yorks.).—*River Wall.*—The Ouse Navigation Trustees have accepted the tender of Messrs. K. Holst & Co., at £3,640, for the construction of a reinforced concrete and timber river wall on the west side of Naburn Cut.

Scarborough.—*Concrete Roof.*—The Corporation has accepted the tender of Messrs. Whitaker & Co., Ltd., Leeds, for the construction of a reinforced concrete roof, covering 7,600 yards, at Osgodby, near Scarborough.

Worcester.—*Concrete Bridge.*—The Worcestershire C.C. has accepted the tender of the Yorkshire Hennebique Contracting Co., Ltd., at £10,559, for the construction of Holt Fleet Bridge. Other tenders submitted: T. Vale & Sons, Ltd., £11,278; Hobrough & Co., Ltd., £12,688; L. J. Speight, Ltd., £13,005; Gray's Ferro-Concrete Co., Ltd., £13,097; Purdie, Lumsden & Co., Ltd., £15,889; Reinforced Concrete Construction Co., £17,633.

MANCHESTER MUNICIPAL

COLLEGE OF TECHNOLOGY

DEPARTMENT OF BUILDING

SESSION 1927–28

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CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XXII. No. 9. LONDON, SEPTEMBER, 1927.

EDITORIAL NOTES.

Reinforced Concrete Racecourse Stands.

IN this number we give the winning designs in the 1927 " Concrete and Constructional Engineering " Prize Competition at the London University School of Architecture. The prize is awarded annually by the proprietors of this journal for competition amongst the students of the school with the object of interesting young architects in the design of structures in reinforced concrete. The drawings are judged by a jury, this year consisting of Mr. H. V. Lanchester, F.R.I.B.A., Professor A. E. Richardson (Professor of Architecture at the School), Mr. L. Gill, F.R.I.B.A., and Mr. H. O. Corfiato, S.A.D.G.

The subject set was " A design for a Reinforced Concrete Stand for a Racecourse," and in considering their award the jury considered the following points: (1) The appropriate expression of the material when concrete is the principal medium of construction; (2) The general qualities of the plan.

The design placed first, by Mr. H. Kendall, is not only an admirable expression of the use of reinforced concrete, but also shows considerable skill in planning and general arrangement. The long horizontal lines inseparable from a structure designed to accommodate spectators at different levels are relieved by the vertical lines of the Royal Box. The two balconies are cantilevered so that there are no columns or supports to obstruct the view. A flat roof is to serve the purpose of an open-air luncheon and tea garden. The Royal Box, octagonal in shape with a dome roof, is in an angle, so placed that although apparently recessed from the general frontage of the stand it commands an unobstructed view in all directions. The plan indicates that the stand would be erected at a bend in the course, the two sections pivoting upon the Royal Box. Thus the occupants of any part of the stand have a clear view in both directions. It will be noted that the Royal Box is not central, so that one section of terracing is more than twice as long as the other; the longer section is placed along the straight part of the track, no doubt in view of the fact that most spectators prefer to see the finish of a race from a position a little behind the winning-post. The whole conception is an admirable piece of work which does credit to the author and the School.

While the design placed second, by Mr. B. M. Johns, is well planned and would have an imposing appearance, it does not so happily indicate the material of which it is built. It would also probably cost far more to erect than the winning design. Reinforced concrete is not a material that lends itself to "fussiness" in design; a straightforward design for requirements usually leads to the best architectural effect and at the same time is the most economical in execution.

Cement Prices.

During the past few years rapid strides have been made in the improvement of the quality of Portland cement, the most notable of which, of course, is the introduction of rapid-hardening Portland cement. Manufacturers have, in fact, concentrated their efforts on the production of Portland cement of a uniform high quality, and very large sums have been expended on new machinery and factory extensions to cope with the increasing demand. In spite of its superior quality, Portland cement has shown the smallest increase in price compared with pre-war prices of practically any building material, and this has now been further reduced as from August 1 last. The price reduction applies to both ordinary Portland cement and rapid-hardening Portland cements made by leading British manufacturers; the price of aluminous cement remains as before.

The lower price of Portland cement should considerably assist the progress of the concrete industry by permitting a small reduction in the costs of concrete construction. In works in which the cost of materials accounts for a large proportion of the total cost, such as roads, this price reduction will be particularly welcome, and give concrete an even better opportunity of competing with other materials.

Design for Reinforced Concrete Bridge at Prague.

PROPOSED SPAN OF 886 FT.

THE population of Prague, the capital of Czecho-Slovakia, now 800,000, is growing so rapidly that the demand for houses has become a serious problem. An ancient fortified town, it occupies a rather restricted site and is separated from the hills which surround it by deep valleys, which render the question of extension very difficult.

In order to allow for further growth, it was decided to connect the town to the suburbs of Pankrac by a huge bridge passing completely over the Nusle valley, and also over existing roads and buildings. The total length of such a bridge would be about 600 metres, 300 or 400 of which would be above the level of the buildings in the Nusle valley. The width would be 21 metres, 14·50 metres for the roadway and 3·25 metres for each pavement. Two tracks of tramways were to be provided along the middle of the road.

A competition was organised for the design of the bridge. There were 29 entries, 13 of which were in steel, and 16 in reinforced concrete. All the reinforced concrete designs, with one exception, necessitated the demolition of a more or less large number of houses to allow for the erection of the intermediary piers. The exception was the design of M. Muzak, of Brussels, who has studied the possibility of reducing the size of the piers to a minimum without reducing the strength. This design is illustrated herewith by the courtesy of M. Muzak, who writes :

Whilst others, with the same end in view, have commended the hollow arch, this design goes a step farther ; seeing that the under sides of a hollow arch have no real structural use, and that the appearance of such an arch must of necessity be heavy and awkward, in this design the undersides are pierced. By this method it is possible to build an arch 270 metres in length.

This project does not necessitate the demolition of any houses in the valley, or interfere in any way with the development of the locality. From the hill to the river the roadway is carried on two pairs of arches 58·50 metres in length ; from thence the roadway is suspended over the centre of the town from two twin arches of 270 metres ; it is then carried on a pair of arches like the first, and finally reaches Pankrac in a series of small arches.

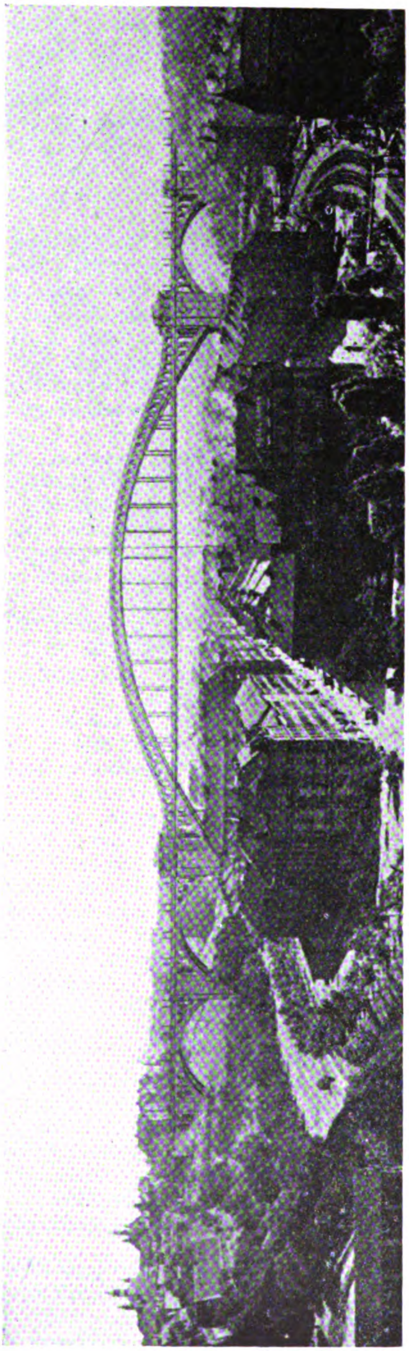
The most remarkable part of the design is, of course, the middle span. Each of the ribs consists of four members connected by vertical and horizontal beams. Thus on all four sides of the complete rib there are octagonal openings. The cross-beams are stiffened by a diagonal bracing at intervals of 13·30 metres.

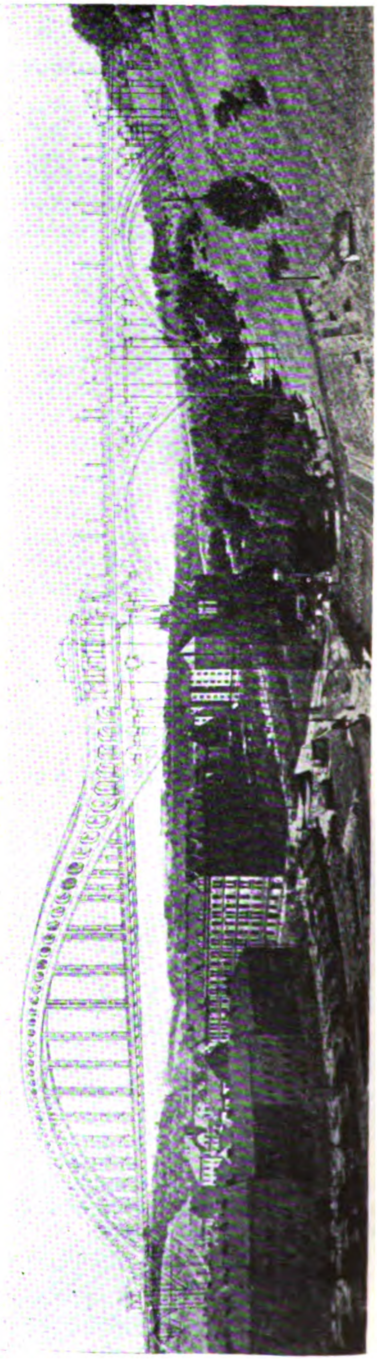
The vertical distance between the members increases progressively towards the ends ; while the lower members maintain a perfect parabolic design, the upper ones follow this design on the largest part of the arch, but at the ends follow an inverse parabolic design. They meet the piers 6 metres above the pavement, thus allowing pedestrians to walk for a distance of about 30 metres in a covered gallery formed by the arch.

The roadway is carried to the ends by small arcades resting on the string. In the middle, the designer, anxious to avoid the useless addition of tie-beams, but at the same time to ensure the greatest possible efficiency, has suspended the roadway by pairs of tie-beams connected by cross-beams. These tie-beams measure 60 cm. by 60 cm., square, and have a hollow cylindrical core. They are joined under the pavement to the longitudinal beam which also carries the cross-beams of the roadway. These longitudinal beams are also pierced.

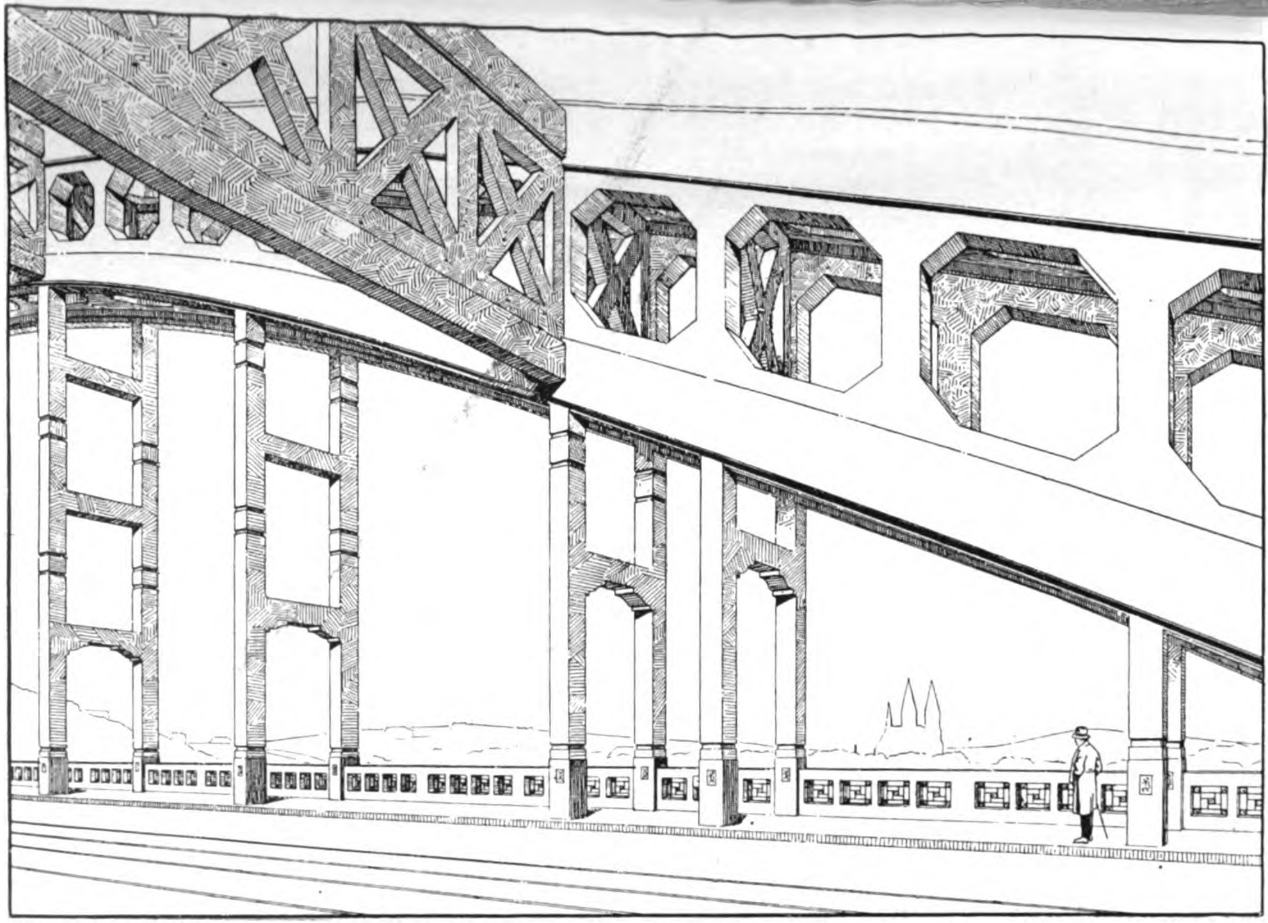
From the static point of view the arches may be considered as interlaced and lightened to within 50 metres from the springings by an arrangement out of the perpendicular. This, whilst maintaining the continuity of the arch, reduces the weight and at the same time ensures a greater rigidity and a greater guarantee of stability.

The foundation of the piers goes down to slatey rocks under 5 metres of clay. The lower part of these large piers is composed of a building of a proportion approaching that of the buildings already



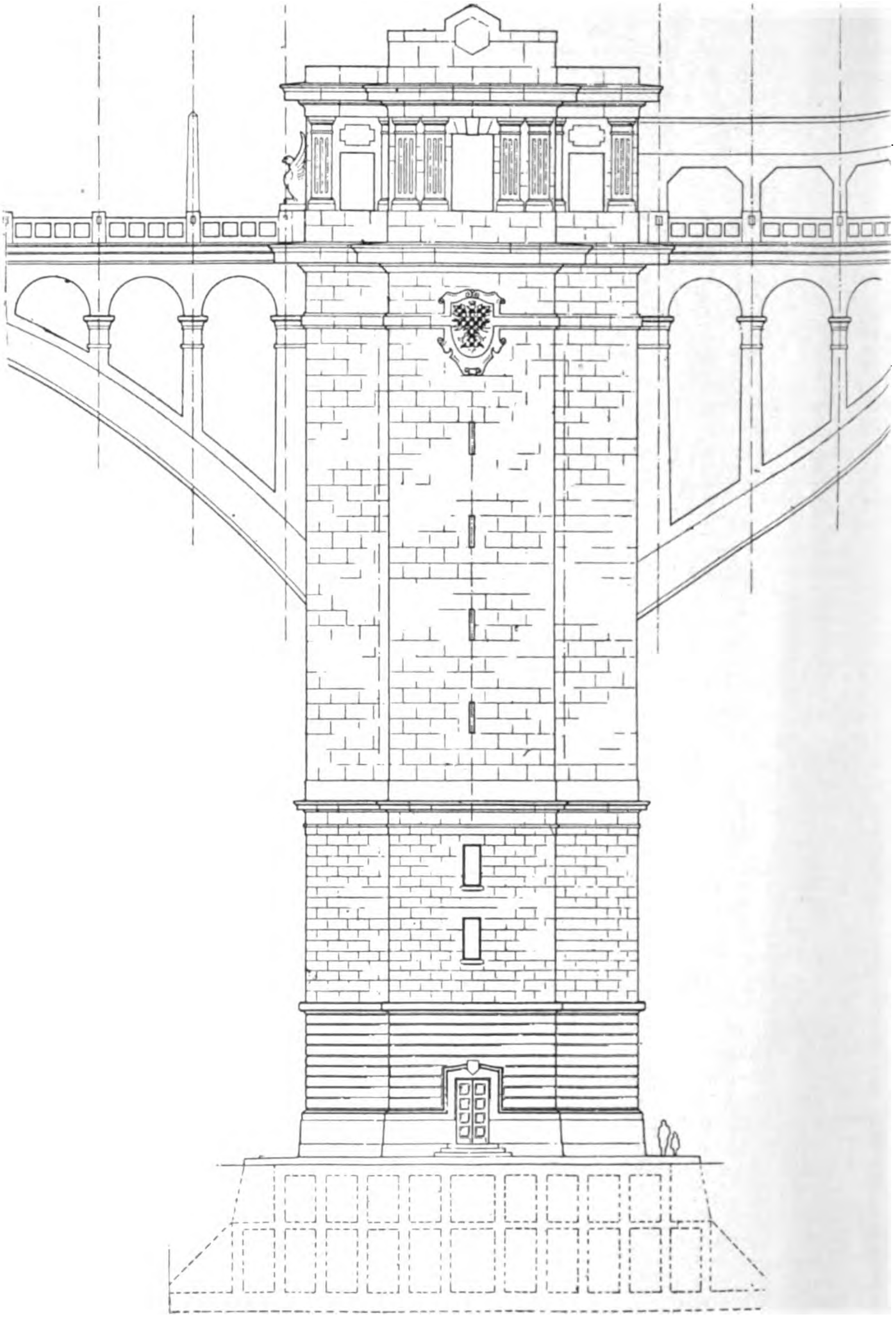


Design for a Reinforced Concrete Bridge at Prague: Centre Span 886 feet.



Design for Reinforced Concrete Bridge at Prague.

Showing Design of Arch Ribs, Ties, and Crossbeams



Design for Reinforced Concrete Bridge at Prague : Elevation of Pier existing in the valley, and surmounted by an arch.

No principle of construction is sacrificed in this project to the requirements of architecture, but the designer has had no illusions. The largest arch in reinforced concrete actually constructed has only 132-metres span, and no doubt confidence in the capabilities of a new material will have to be strengthened before a bridge of 270-metres span is built.

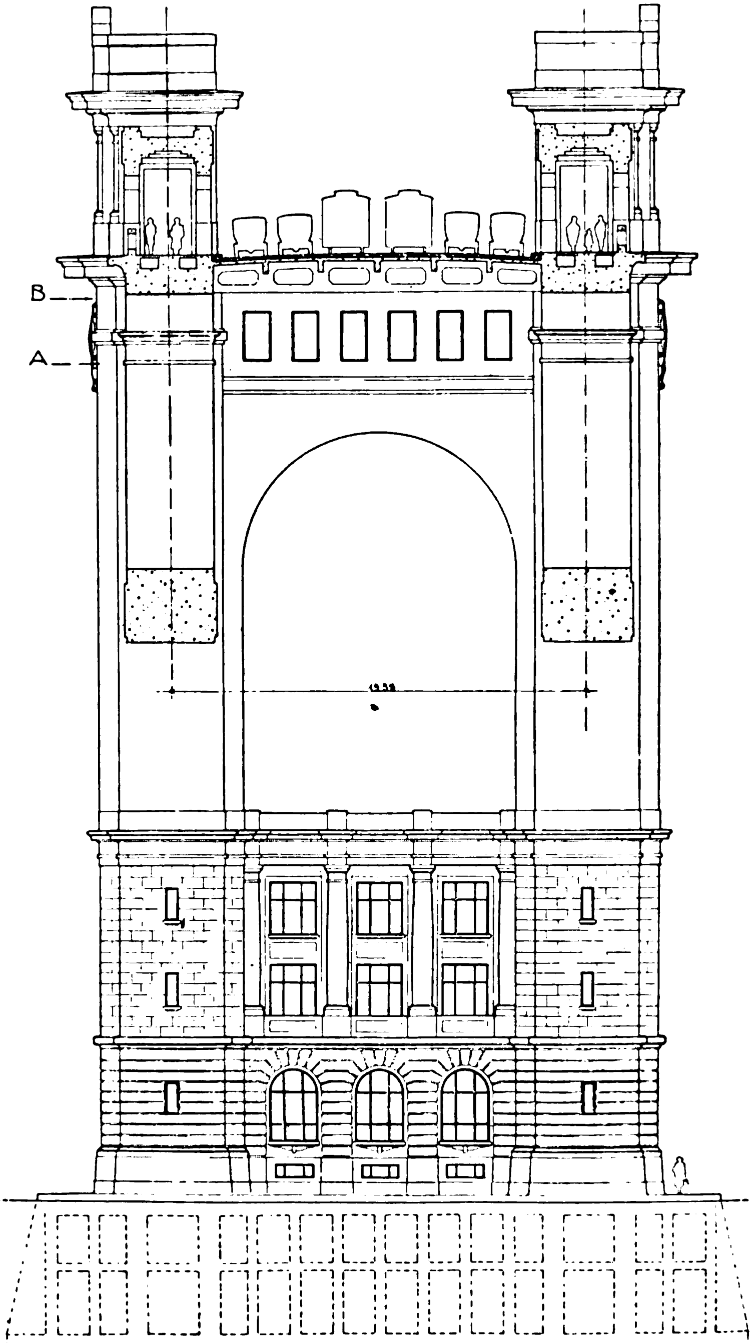
Soap as Concrete Waterproofer.

SOAPS added in the concrete mixer are, according to a paper read before the American Concrete Institute by Messrs. A. H. White and J. H. Bateman (Professors of Chemical Engineering at the University of Michigan), effective in preventing the absorption of water by capillary action, even when added in very small amounts, if they are added in such a form as to ensure extremely fine subdivision and dispersion in the concrete. As little as 0·05 per cent. of fat acid in the form of soap based on the weight of concrete is sufficient if it is finely divided and uniformly distributed, and if the concrete is well made and not cracked. Soaps will not in themselves entirely prevent the penetration of water under even rather slight pressure, but they will be of assistance. If the concrete is well made and thoroughly cured, the colloid near the surface swells when it becomes wet and fills the pores so completely that the penetration of water may stop before the water has progressed many inches from the surface, even if the concrete is not waterproofed.

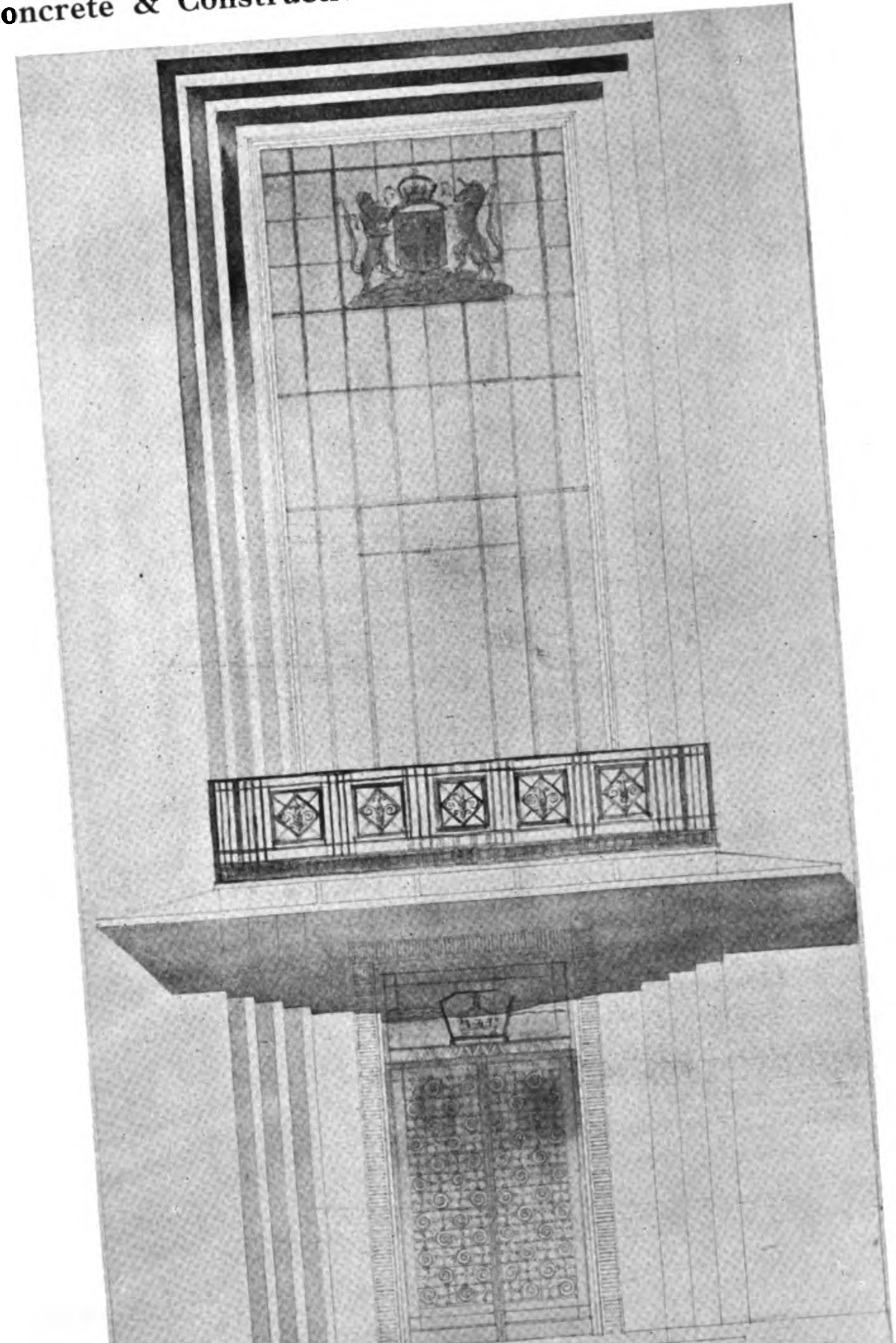
This ability of plain concrete to resist water comes only with time and the development of sufficient colloid to fill the pores. Concrete which becomes dry within a few days after it is made does not possess sufficient development of the colloid to prevent the absorption of water. Soaps are as effective in fresh concrete as in that which has aged and assist in preventing the penetration of water even under pressure. In so far as the concrete becomes wet it expands, and it contracts when it becomes dry, irrespective of the presence of soaps, which are effective only in preventing access of water.

The strength of concrete is not impaired by the addition of soaps in the proportions stated above, provided it is kept damp continuously after pouring until it has attained the desired strength and provided the soaps have not caused foaming and consequent entrainment of air. The strength of concrete of a given composition is a function of the amount of cement which has reacted with water and may be plotted as a function of the water held in combination. Plain concrete which has been allowed to dry and subsequently becomes wet will resume the hardening process and gain in strength. Concrete containing soaps gains strength very slowly after it has once become dried because it resists the absorption of water. Special pains must, therefore, be taken to keep concrete containing soaps damp for at least seven days if it is to attain a strength comparable with plain concrete.

The shrinkage of concrete on drying is a function of the quantity of cement and the degree of its hydration and will not be lessened by the use of soaps. The same precautions must therefore be taken to prevent shrinkage cracks in waterproofed as in plain concrete. Soaps are not able to prevent the penetration of water through cracked concrete. They will retard the penetration of water into dry concrete, and therefore help in preventing volume changes due to alternate exposure to wet and dry conditions. If the concrete is kept damp until it is properly cured, there should be only slight diminution in strength due to the waterproofing. Conditions may readily arise in service where the waterproofed concrete will be distinctly stronger than the plain concrete. A concrete slab wet and expanded on one side and dry and contracted on the other side is subject to powerful shearing stresses which weaken it materially. A slab which is waterproofed should not absorb water to nearly the same extent and therefore should not be weakened so much under similar adverse conditions.

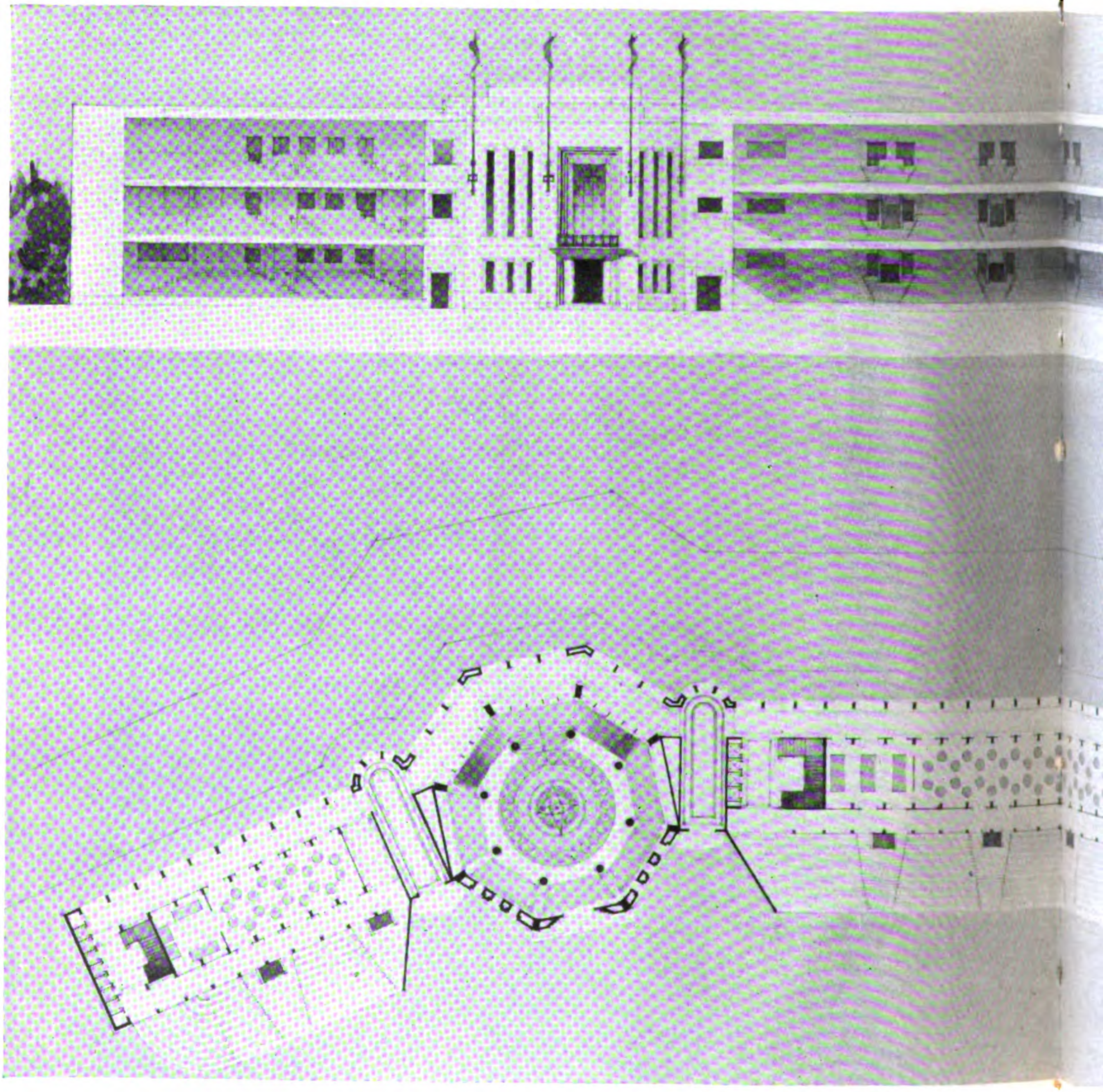


Design for Reinforced Concrete Bridge at Prague: Section at Pier.
(*See p.* 523.)



REINFORCED CONCRETE GRAND STAND FOR A RACECOURSE: DETAIL OF ROYAL BOX.

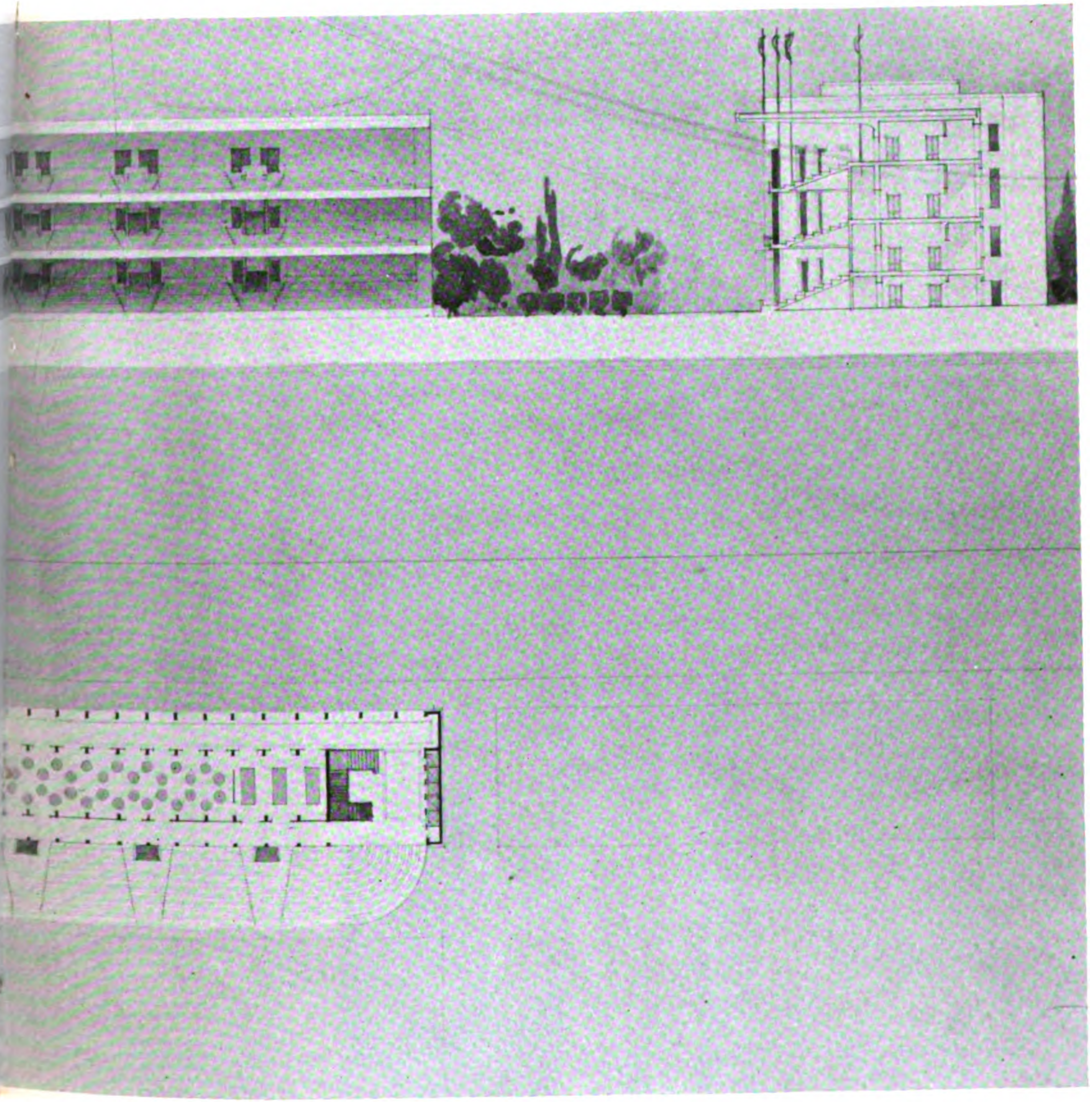
By Mr. H. Kendall. (*See pp.* 530–1.)



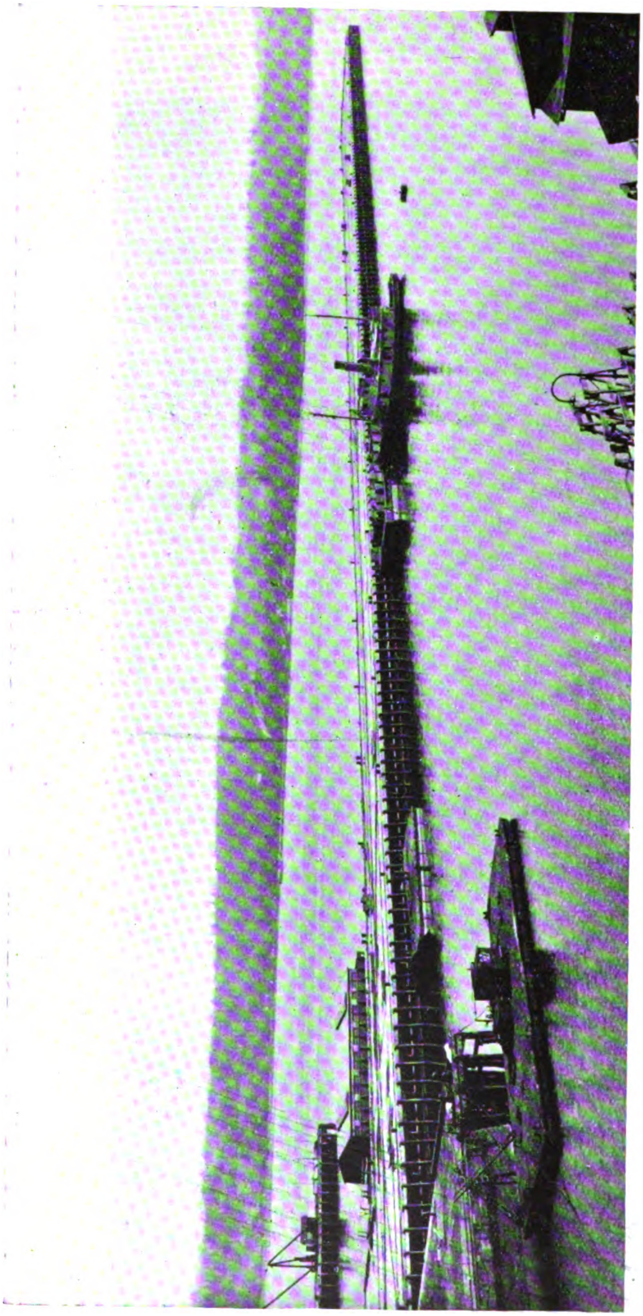
REINFORCED CONCRETE GRAND STAN

Design placed first. By Mr. H. Kendall

Engineering" Prize Design.



D STAND FOR A RACECOURSE:
Kendall. *(See pp.* 529 *and* 546.)



General View of Pier at Puget Sound Navy Yard. *(See p. 533.)*

Sea-water Structure constructed with Aluminous Cement Concrete Foundations.

By **W. F. WAY.**

Introduction.

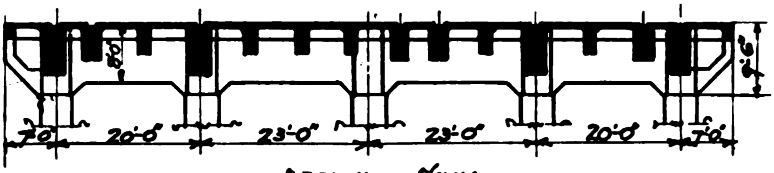
WITH the completion of Pier No. 6, the Repair and Fitting-Out Pier at the Puget Sound Navy Yard, another type has been added to the many types of existing reinforced concrete sea-water structures. Table I gives a short description of the structure built at the Navy Yard, where five distinct types are in existence. Naturally the later piers have profited from the experience gained in the construction of the earlier piers and from the general progress in reinforced concrete construction, which has changed considerably during the period of fourteen years.

TABLE I.

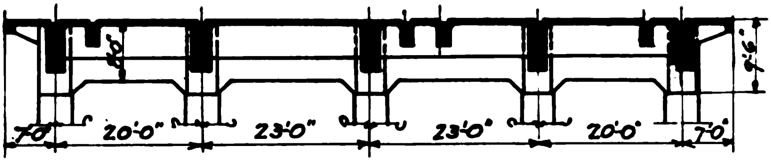
Structure	Date	Size	Foundation	Deck
Pier No. 8	1911	60 ft. by 402 ft.	Diameter of cylinder shaft, 3 ft.; base, 6 ft. Shell 3 in. thick, of 1 : 2 mortar. Seal made with bottom-dump bucket. Core mix 1 : 2 : 4. Soil bearing.	Structural steel encased in concrete with concrete slab.
Pier No. 4	1913	80 ft. by 480 ft.	Diameter of cylinder shaft, 4 ft.; base, 11 ft. Cylinder poured in place in watertight wood forms. Mix 1 : 2 : 4. Seal made with tremie.	Monolithic deck construction of reinforced concrete. Beams narrow and deep. Mix 1 : 2 : 4.
Pier No. 5	1921	80 ft. by 1,200 ft.	Cylinder shaft diameter 4 ft. 6 in. and 4 ft., with 13 ft. and 11 ft. bases respectively. Pre-cast shells 6 in. thick in Portland cement concrete of 1 : 2 : 2 mix. Cylinder sunk and core poured by pneumatic method.	Same as Pier No. 4, except mix was 1 : 3·75 : 4·25.
Pier No. 4 Extension	1923	80 ft. by 720 ft.	Same as Pier 5.	Deck beams and girders pre-cast Portland cement concrete, 1 : 3·75 : 4·25 mix. Slab poured in place.
Pier No. 6	1925–6	100 ft. by 1,318 ft.	Cylinder shaft 4 ft. 6 in. with 15 ft. 3 in. base. Pre-cast shells 6 in. thick in high alumina cement concrete of 1 : 2·3 : 3·5 mix. Cylinders sunk and core poured by pneumatic method.	Beams and girders broad and shallow. All poured in place. Mix 1 : 2·3 : 4·25.

Pier No. 6 was designed for a uniform live load of 900 lbs. per sq. ft. for all areas except that portion adjacent to the 350-ton stationary crane, where the load was increased to 1200 lbs. per sq. ft. The moving loads on the standard-gauge track were equal to those of a 30-ton locomotive crane while those for the 20-gauge tracks were equal to the loads of the 50-ton dry dock crane. With the boom in the critical position the first eight wheels have a reaction of 83,000 lbs. each and the second eight wheels 40,000 lbs. each; the wheel spacing is 3 ft. 9 in. All live loads were reduced as follows:

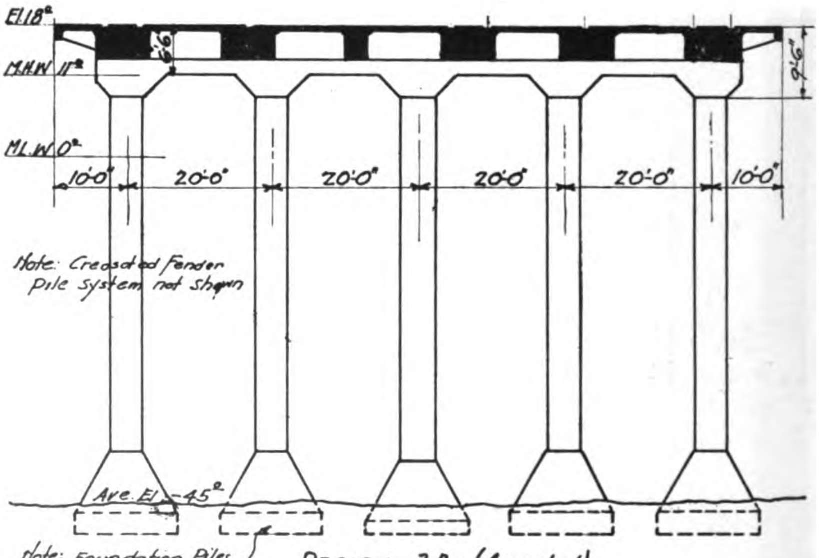
Slab and panel beams, no reduction; longitudinal beams, 10 per cent.; cross girders, 20 per cent.; cylinder foundation, 30 per cent. The load on the foundation piles was 25 tons per pile.



DESIGN — NAVY



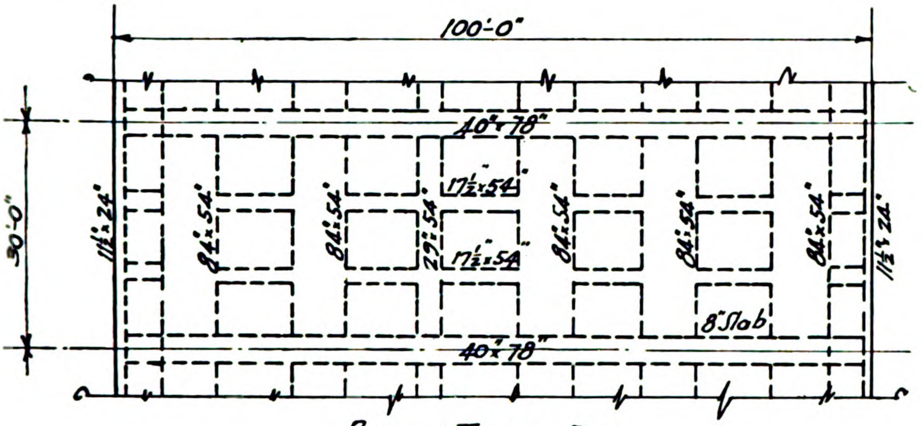
DESIGN — 3F



DESIGN 3B-(Accepted)

– QUANTITES for 30 foot TYPICAL BAY –

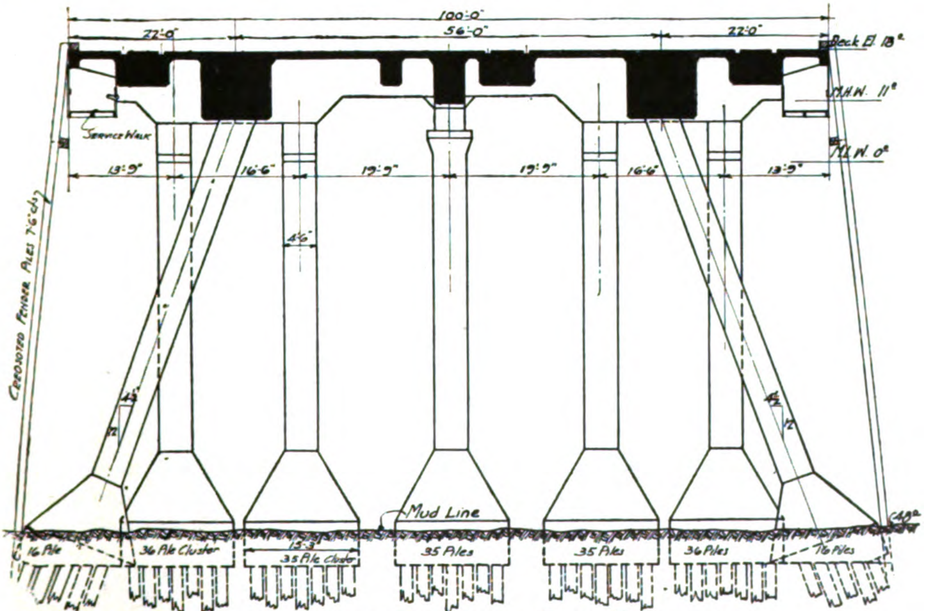
DESIGN	3B	Navy	3F
Concrete, Cubic yards	320	295	285
Reinforcing steel, pounds	70 000	88 500	72000
Formwork, sq. ft	6 000	8400	7400
Total number of slab panels	21	60	40
Number of slab panels of different size	3	24	15
Relative Cost - Estimated	1.00	1.14	1.08



PLAN of TYPICAL BAY

The unit stress in the reinforcing steel was limited to 12,500 lbs. per sq. in.; this low figure is used by the Navy in order to obtain small deflections. The concrete stress was limited to 600 lbs. per sq. in. (for 2000 lbs. concrete), except for negative moment over supports when the allowed stress was increased to 750 lbs. per sq. in.

The concrete mix for the aluminous cement concrete was 1 : 2 : 3·3; these proportions are for a dry rodded mix. The average field mix, after making proper allowance for bulking, was 1 : 2·3 : 3·5. The cement content was 6·23 cu. ft. per cubic yard of concrete. A slump of 6 in. to 7 in. was used, and the average compressive strength of the 6 in. by 12 in. test cylinder was 4825 lbs. per sq. in. in 24 hours and 5256 lbs. per sq. in. in 28 days. The dry rodded mix for the Portland cement concrete cores for the foundation cylinders was 1 : 2 : 4, and the field mix was 1 : 2·3 : 4·25. With an



~ CROSS SECTION AT CRANE FOUNDATION ~

average slump of 2 in. the 28-day strength was 3196 lbs. per sq. in., and for 60 days 4101 lbs. per sq. in. The cement content was 5·6 cu. ft. per cubic yard. This mix was also used for the deck construction, but the water content was increased to give a slump of 4 in. and naturally the strength fell to 2726 lbs. per sq. in. in 28 days and 3548 lbs. per sq. in. in 60 days. The concrete cover on all main members was 2½ in., and on the slab 1 in. All concrete was mixed for at least one minute after all ingredients were in the mixer drum.

Design and Construction.

The problem of determining the most economical design for a pier of this character naturally requires considerable study, and the solution must necessarily vary with the contractor's experience and equipment. It is the problem of determining the design of the minimum cost and involves not only quantities of materials but also unit prices, which unit prices, dependent upon the simplicity and uniformity of lay-out, upon adaptability to use of contractor's equipment, and especially upon the amount of tidal interference with the deck construction, are factors quite as important as the various amounts of materials involved. In the design which was accepted by the Navy Department, and in accordance with which the pier was built, the above conditions for low cost were all met and fairly well satisfied.

Several sets of preliminary designs and lay-outs were made. The criterion selected by Waddell for economical bridge construction, namely, that the cost of the substructure should equal the cost of the superstructure, was taken as the basis for comparison. In these comparisons, all constant items such as fender system, trackage, bituminous carpet, bollards and cleats, etc., in the superstructure, and the foundation piles in the substructure, were disregarded.

The importance of uniformity of construction should be emphasised. While concrete piles were not applicable for use in the outboard portion of this pier, they could have been used in the inshore portion. A combination of concrete cylinders and piles involved, however, two separate and distinct plant lay-outs, and it was unquestionably more economical to use the cylinders throughout. Apart from cost, it is believed that the cylinder type of construction has advantages over pile construction, especially where heavy live loads are to be handled.

As a matter of comparison, a 4 ft. 6 in. diameter cylinder, similar to those used, has the load-carrying capacity of eighteen 18-in. square reinforced concrete piles. In the piles, there is 3·7 times the amount of steel and 2·65 times as much concrete as in the cylinder, but decidedly more important is the fact that the piles have 6·8 times more surface of exposure between tides than the cylinder. Further, it is believed that the concrete in the cylinders, due to the elimination of handling and driving stresses, is in better condition than would have been the case had piles been used. It is safe to say that the cylinders contain practically no cracks, but the same statement with respect to pre-cast concrete piles cannot be made with equal assurance. While the minute cracks in reinforced concrete piles have not been proved to be vital, and especially when they occur below low water, still the elimination of any cracks in reinforced concrete in sea water should be considered advantageous.

From a number of lay-outs studied, two plans were given serious consideration. They are illustrated with the plan prepared by the Navy and shown on p. 534. From available data it was decided that design 3B was the most economical as indicated by the above comparison. It is fully realised, however, that this decision depends upon the unit prices used, and that others might arrive at different conclusions. The principal advantages in design 3B are are follows :—

(1) Equal spacing of cylinders in the bents, which simplified the temporary bracing to hold them in position until the deck was poured.

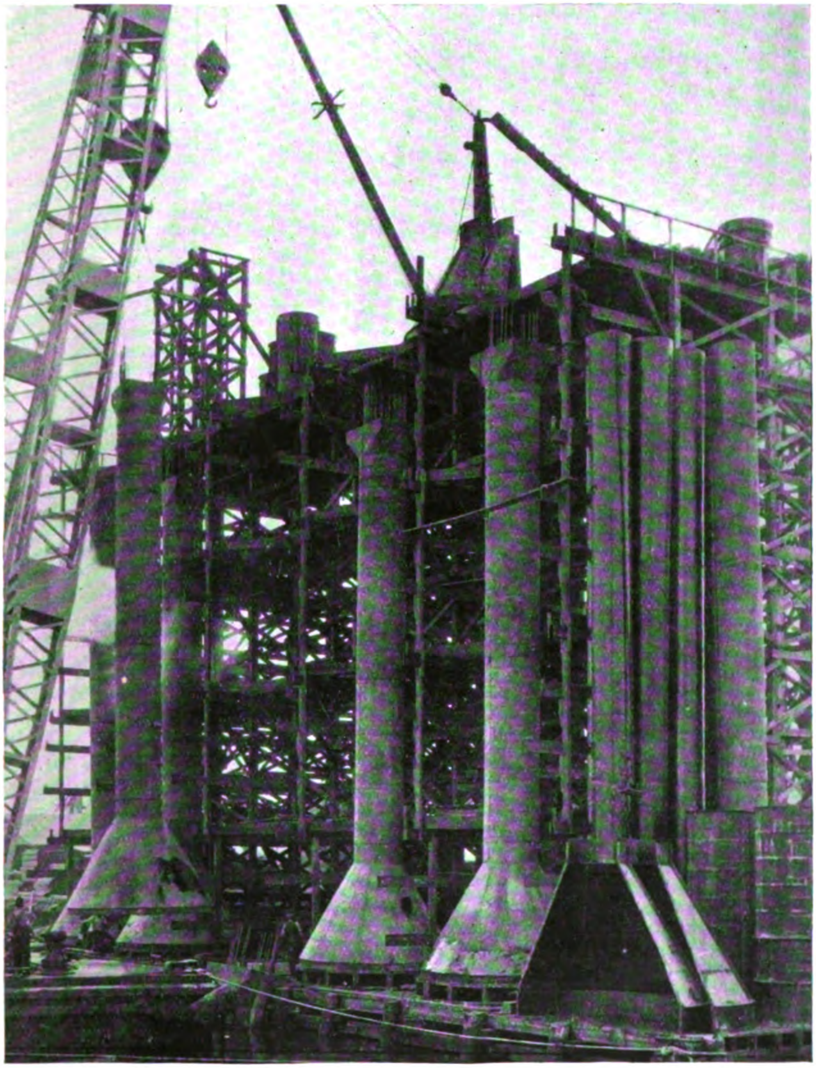
(2) Same elevation for bottom of all longitudinal and panel beams.

(3) Minimum amount of formwork, which means a minimum amount of surface exposed to the elements.

(4) Formwork typical (it will be noted that there are but three sizes of deck panels and that all longitudinal beam sides are the same).

(5) Practically all formwork is above ordinary high water, which allowed uninterrupted work.

(6) Wide spacing of reinforcing bars,



Five Soil-Bearing Cylinders ready to be removed from Casting Platform, showing inner Shaft Forms and outer Bell Forms.

with consequent facility for placing concrete.

The fact that all members were of such a size that a workman could easily enter them and clean them out, or adjust misplaced reinforcing steel immediately before the concrete was poured, is of importance, and is a practice that might well be followed in all outside construction work. The breadth of the main deck beams (7 ft.) is somewhat unusual. The primary reason for this was to permit the heavy-moving standard-gauge crane loads to be carried by one beam. Separate beams under each rail were first considered. With two beams, however, it was necessary to design each beam to carry the maximum crane load which occurred when the crane boom was at an angle of 45 deg. with the centre line of the track; but in this position the beam on the side opposite to the boom carried practically no load whatever.

It therefore proved much better to combine the two individual beams, which naturally resulted in a great reduction of total crane load for the one combined beam over that used for the two separate beams. The tendency for torsional stresses in the one beam when practically the total load was on one rail, was counteracted by the cross-panel beams. A further benefit of the use of this wide beam is the fact that 35 per cent. of the uniform live load was carried directly to the cross-girders. The width of the main beams also materially reduced the span of all transverse beams.

One-and-a-half inch round deformed bars were used for all main tensile reinforcement, and all stirrups in the main members were either ⅞ in. round or 1-in. round. The use of these sizes reduced the number of bars to be handled to a minimum and afforded better embedment and placement; also, for this reason round bars were used exclusively.

All members of the deck were designed as continuous members. The graphical spline method and the analytical method of coefficients developed by H. M. Hadley were used for stress determinations. All calculations were checked by the Bureau of Yards and Docks using the theorem of three moments.

The pier is provided with two expansion joints of the cantilever type. This provision allows an entirely free longitudinal movement, but does not permit horizontal displacement due to a system of concrete lugs on one cantilever fitting in pockets built in the adjacent cantilever. The joint has worked very satisfactorily, and regular movements occur with varying day and night temperatures. From observations taken it was found that there was ⅜ in. movement with a change of 17 degrees temperature of air, which in 600 ft. amounts to a coefficient of 0·000029, or about one-half the established temperature coefficient of expansion of concrete. This difference is probably due mostly to restraint offered by the cylinders and to the concrete having less temperature change than air.

As stated, it proved more economical to use cylinder construction throughout. Soil-bearing cylinders were required for the inner half of the structure, where suitable foundation was found from 4 to 18 ft. below the mud line. In this work the cylinders were set in place, weighted, and equipped with an air-lock, after which they were entered and worked down by blowing the spoil out under the cutting edge so long as reasonable progress was made, which depended upon the character of the soil and the depth of cutting edge. Following this the cylinders were sunk to grade by hoisting the spoil out through the air-lock in buckets.

For the outboard half of the pier the foundation cylinders were carried by untreated pile clusters. This work was handled in the same manner as on the previous piers. On the extreme outboard end, piles up to a length of 107 ft. were used. Due to the very soft overlying material on the bottom, these piles would settle approximately 50 ft. under the weight of piles, follower, and hammer. They were driven to refusal with a 5000-lb. steam hammer and 60-ft. steel follower, which weighed about 10,000 lbs. and incidentally reduced the effect of the blow 50 per cent. due to its weight.

In the crane foundation, where 36 piles were placed under a 14 ft. 6 in. inside diameter cylinder bottom, or 2 ft. 3 in. centres, remarkably accurate driving was revealed.

The cylinder shells for this pier were originally designed in Portland cement concrete, and it was the intention to cast them in a manner similar to that used for Pier No. 5 and Pier No. 4 Extension*. The change to the use of high alumina

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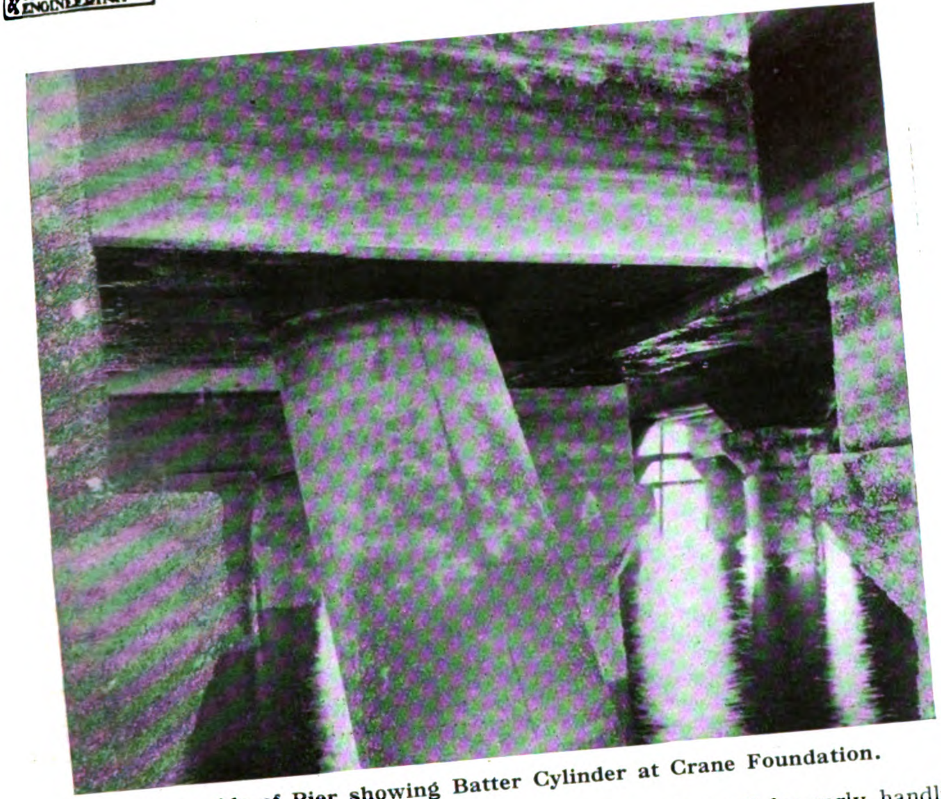
* See CONCRETE AND CONSTRUCTIONAL ENGINEERING, May, 1924.



Underside of Pier showing Batter Cylinder at Crane Foundation.

cement was made after the contract was awarded, and resulted in a reduction in the contract price. Full credit for this change is due to the Navy Department, who had previously investigated this material and satisfied themselves as to its fitness for this work.

The use of high alumina cement for the cylinder shells meant an immediate increase in cost of shells over Portland cement of 45,000 dollars. Saving was, however, effected as follows: The Portland cement cylinder shells required the use of an elaborate casting and assembling yard located three or four miles from the site of the pier, and consequently another complete mixing plant would have been necessary. The method used on the earlier piers, of casting the bell sections and cylinder shafts, would have been employed and the labour of tipping and turning the sections, rolling them on to the skidway, assembling them, pouring the splices, launching, and carrying them to the pier site would have been required. The stresses induced by early handling required a material increase in reinforcement and shell thickness in the bell sections, as also did the splicing of the sections.

In contrast with this the use of high alumina cement permitted the entire 234 cylinders required for the job to be cast on a small timber pier 20 ft. by 100 ft. immediately adjoining an existing timber pier, and also permitted the stripping of forms and immediate installation in the pier when the cylinders were only 24 hours old.

The adopted method of casting the bell and cylinder shaft in a vertical position in one complete unit, and the handling method employed, permitted the pre-cast sections to be of minimum thickness and with minimum reinforcement, and effected a considerable saving of these materials. Certain risks were naturally involved in this previously-untried operation, but the advantages to be gained seemed sufficient to warrant the adoption of the design and method of construction and it was therefore selected. In actual results the use of the high alumina cement and the method for casting cylinders fully justified the contractor's decision regarding them.

The small casting pier, as stated above, was 20 by 100 in plan. On this, covering the entire area and extending 25 ft. on the existing structure, was erected a working tower 60 ft. high with four platforms at different elevations. A 12-in. stiff-leg derrick with 60-ft. boom was erected on the top of the tower. By means of this derrick all the forms were handled, the skeleton cages of the reinforcing steel placed in position, and all additional reinforcement handled. On the water side of this tower were the five bays where the cylinders were cast and from which the floating stiff-leg derrick swung them into the water with only a few inches lift and then carried them to the site.

Forms were provided for five complete cylinders. Inside shaft forms of steel were made in one unit and constituted a hollow cylinder 3 ft. 6 in. diameter and 45 ft. long. This was cut for its entire length along one element. The outer shaft forms were made of semi-circular section in about 15 ft. lengths. The outer bell forms were also in semi-circular sections.

The success of this method of cylinder construction hinged upon two vital factors, the first of which was the ready and easy removal of the inside bell form, and the second was making this form of such shape and section as to permit one form to accommodate itself to six different changes in the vertical height of bell sections. On previous jobs the height of the bell section had been kept constant and the bell diameters varied to suit the pile clusters. By holding the outside bell diameter constant, however, and by varying the height of the bell section, the same result was accomplished without the use of any additional material and with a very considerable simplification of work and saving in cost.

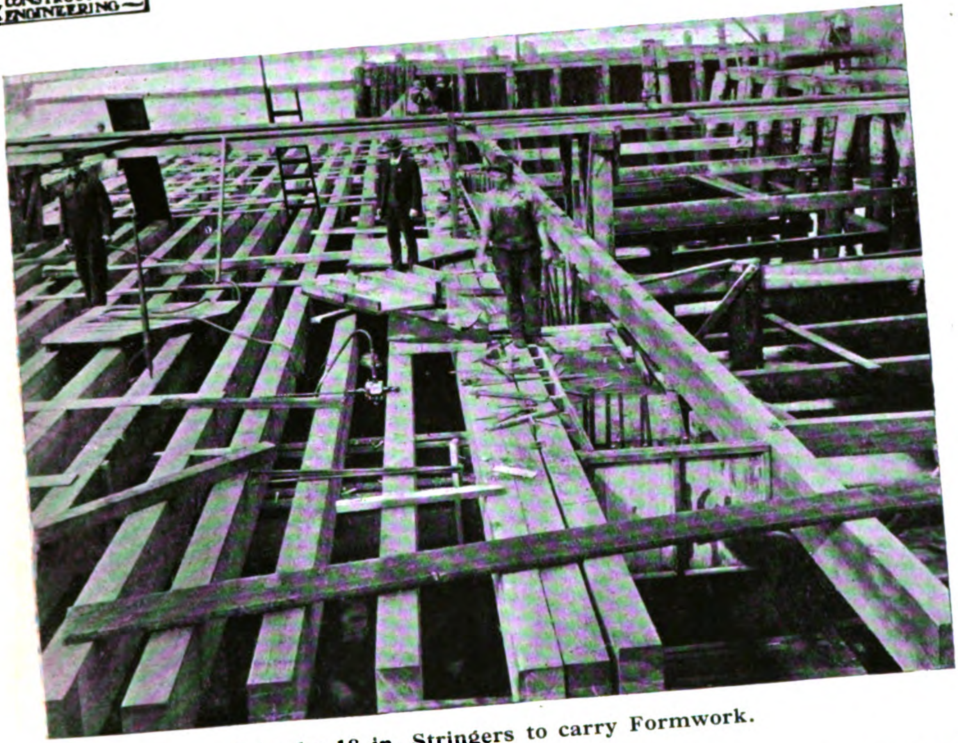
The inner bell forms were made of wood and covered with sheet metal. Only one set—five in number—was used on the job. The deck of the casting pier contained circular holes to allow the removal of these forms by lowering them into the water, where they floated freely until required again. When in use they were supported at the desired height by dogs which framed into the deck structure. This feature worked admirably and contributed largely to the success of the cylinder construction.

The concrete was mixed on a floating mixer, handled from there by bucket to a concrete hoist which elevated the concrete to the desired platform. The concrete was taken by buggies from hoist to cylinders. It was dumped into the forms at two places diametrically opposite each other, and tamped by rods and by vibrating the forms with pneumatic hammers.

Forms were removed in from sixteen to twenty hours, and twenty-four hours after the concrete had been placed these large cylinders, weighing on an average fifty tons, were rigged with cable chokers 15 ft. to 20 ft. below their tops, lifted a few inches above the pier deck by the floating derrick, which then, with its load, backed clear of the pier to lower the cylinders into the water. An average of two cylinders complete per day was maintained.

The cylinders were set in place with the same floating shearleg derrick used in removing them from the casting pier. The general design of the bracing system to hold the cylinders in line after being set was practically the same as employed during the construction of Pier No. 4 Extension. The pneumatic method employed in sinking the cylinders and pouring the cores with concrete was also similar to previous methods used. The air-lock and concrete locks, however, were greatly improved, especially the concrete lock, which was enlarged to hold a full mixer-batch and was attached directly to the top of air lock.

In designing the deck, the system of falsework and method of handling forms was given considerable thought. All work, however, was based upon the idea that the only logical plan was to carry all construction loads by the cylinders themselves, as was done in Pier No. 4 Extension, since with the cylinders in place and amply capable of carrying all construction loads it seemed fundamentally extravagant not to make use of them. By casting the cylinders with an enlarged rectangular top, and at a very trifling expense, they were made suitable for this purpose. On these enlarged tops were



8 in. by 18 in. Stringers to carry Formwork.

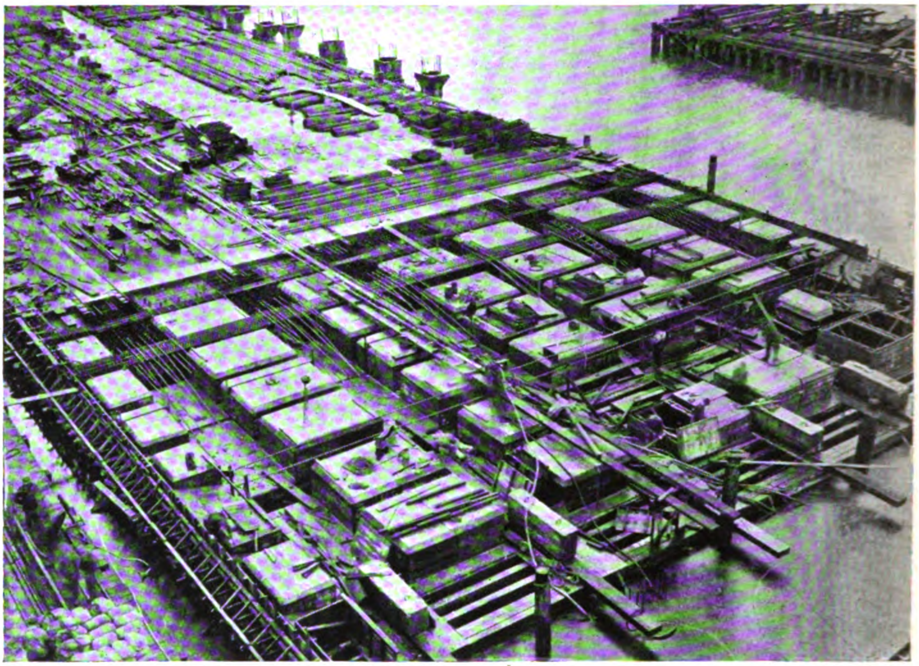
seated heavy trussed beams spanning from bent to bent, a distance of 25 ft. centre to centre of bearings.

With the trussed beams in position a complete deck of 8 in. by 18 in. timbers 20 and 34 ft. in length—18 in. on centres—was laid spanning across them. The use of such large timbers may be questioned as it was necessary to have a sufficient number for eight bays in order to maintain the pouring schedule. However, it is believed that a close study will vindicate their use, especially when it is realised that they entailed no framing or maintenance charges whatever, that they were capable of being freely and roughly handled with the floating derrick, that they were very simple to place, and that at the completion of the work they were found to have a very considerable salvage value. Directly on top of the 8 in. by 18 in. floor the deck forms were placed. Progress demanded forms for about one-sixth of the entire structure, and this amount with ordinary minor repairs proved sufficient for the job. All forms were made in panels and handled mostly by the small floating derrick. The deck concrete was poured with two floating mixers, one on each side of the pier. The concrete was handled from mixer to forms by buckets and a derrick on a mixer scow.

Near the outboard end of the pier a 350-ton stationary hammer-head type crane will be placed, and unusually heavy foundation and deck construction were naturally required for it. Apart from the heavy sections, there is nothing unusual in the framing. The brace cylinders, however, are worthy of comment since the battered foundation piles and the placing of these cylinders involved unusual construction.

The unit cost of this type of structure, after deducting all items not relating directly to the pier and the items of track-work and electric conduits, which are considerably in excess of such installation in commercial pier construction, is 8.30 dollars per square foot.

In comparing this unit cost with other types of pier construction, however, due consideration must be given to the narrow width of this pier, to the heavy live loads



Complete Deck, Formwork and 8 in. by 18 in. Timbers.

and low unit stresses, and to the existing subsoil conditions, all of which were factors tending to increase the cost of this structure.

The general plan of the pier was determined by the Navy Yard under the direction of Captain E. R. Gayler, then Public Works Officer at the Yard. Admiral L. E. Gregory, Chief of Bureau of Yards and Docks, approved the alternative design submitted by contractor. The construction details and all inspection work was done under the immediate supervision of Lt.-Com. J. J. Manning, who was assisted by Associate-Engineer E. C. Jack. For the contractor, Col. J. P. Mackenzie was general superintendent. The engineers and contractors were Messrs. Herry and McFee, for whom the writer is chief construction engineer and who designed the pier and determined the construction methods and details.

Patents and Trade Marks in the Irish Free State.

MESSRS. RAYNER & CO., patent agents, call attention to the new situation which will be created by the passing of the new Patents and Trade Marks Act in the Irish Free State. Previously, British patents and trade mark registrations have covered the whole of Ireland, but when the new Patent Act is in force they will automatically cease to function in Saorstat Eireann.

It is necessary for all holders of British patents and trade marks desiring to retain protection in Southern Ireland to take out fresh patents or trade marks there. British patents granted before 6 December, 1921, will be continued upon the Irish Register if a copy of the patent is lodged in Ireland and renewal fees paid as in England. Similar privileges applying to registered trade marks and designs.

Book Reviews.

"Erddruck, Erdwiderstand und Tragfaehigkeit des Baugrundes." By Dr. H. Krey. (296 pp., 208 illustrations, 117 tables.

Berlin: Wilhelm Ernst & Sohn. Paper, 21.60 mk., cloth, 23.40 mk.

This book deals with earth pressure in all its aspects and the carrying capacity of soil, and is a valuable treatise for engineers wishing to penetrate into the mysteries of the various theories that have been developed during recent years to try to account for the many deviations from the older and generally-accepted theories of earth pressure that constantly occur in practice, and which sometimes, on account of the consequential results in respect of the structures involved, call attention in no uncertain measure to the unreliability of the earth pressure theories in general. Thus the collapse of some important wharves in Sweden gave rise to a serious revision of the old formulæ and the introduction of the new theory of cylindrical planes of rupture, which seems to approach the really existing conditions somewhat more closely than the theory based on plane surfaces of rupture. This former theory and numerous others are all treated very exhaustively and a critical comparison between their respective values is given by the author. He introduces a new conception of earth pressure, the "natural earth pressure," and uses this in developing his formulæ—both for lateral pressure and vertical resistance to loading; his calculation of the carrying capacity of piles is very interesting in its novelty and is based on methods entirely different from the old pile-driving formulæ, for which the author entertains a deep, and perhaps not unfounded, distrust.

The contents of the book are divided into ten chapters, describing the basis and first principles underlying the earth pressure theories and their practical application; the resistance of the soil to lateral and vertical forces; the influence of cohesion on the results previously described; practical examples based on the foregoing formulæ and on the earth pressure tables introduced in the book; and finally a most interesting chapter on the agreement between the author's theoretical representation of the problems and the actual occurrences in a moving body of earth. This chapter contains a series of what almost amounts to moving pictures showing the behaviour of the separate particles of earth under various tests, and from which the magnitude of the movement and the direction of the forces acting are clearly visible. The test box used in these experiments had a glass side through which photographs of the mass of earth contained in the box were obtained, sharp enough to distinguish the individual particles of the soil; slight movements of the end wall of the box cause some of the particles to move and to record their movement on the photographic plate by a line giving the direction and length of the sliding due to this and other disturbances, such as the placing of vertical loads on base plates, the driving and extraction of piles, the side movements of sheet piling, both anchored and free.

A study of these photographs, giving, as they do, the actual happenings in the ground under the influence of everyday forces and disturbances, will be an eye-opener to most engineers, and should be of great assistance in helping to clear one's conception of the phenomena connected with earth pressure generally. For this chapter alone the book is worth acquiring, even although the theoretical matter may be found a little too heavy for the average engineer, and the pictures of course have the advantage of requiring no linguistic skill to decipher.—R. N. S.

"Introduction to Reinforced Concrete Design." By A. Sutherland and N. W. Clifford. 412 pp.

London: Chapman and Hall, Ltd. Price 20s. net.

This book is the combined effort of a professor and a consulting engineer, Mr. Sutherland being Associate Professor of Structural Engineering at the Massachusetts Institute of Technology and Mr. Clifford, a consulting engineer practising in Boston. The result is a useful and fairly comprehensive text-book set out and printed in the excellent manner which is characteristic of many American technical books.

One point of interest is that the theoretical treatment of beams is based upon the equivalent plain concrete section which was first developed in English textbooks by the author of this review.

After an historical note we have a short chapter upon concrete materials, followed by one on proportioning concrete in which the water-cement ratio theory is explained at some length.

Next follow two short chapters upon properties and manufacture of concrete and forms, after which we come to the first long chapter which deals with beams. The treatment here follows upon orthodox lines and has the usual American succinct style, which is suitable for readers having a good mathematical equipment but is rather difficult to follow by the " weaker brethren " who may nevertheless be very good engineers.

After two short chapters upon compression members and formulas, diagrams and tables, we pass to the first chapter upon design proper which deals with retaining walls and is clearly set out. Next follows another design chapter dealing with highway bridges, from which we pass to a short chapter—too short we think—upon continuous beams and rigid frames in which the slope deflection method is outlined. Two useful and very clearly illustrated chapters on building design follow—including a treatment of flat slab floors and the calculation of bending moments in columns. Then we come to one on arches; this, we think, will prove of most value to practical designers and explains at some length Mr. C. S. Whitney's method of simplifying the integrations involved in the elastic arch theory.

The Joint Committee Report of 1924 and excellent diagrams and tables form the bulk of a rather lengthy appendix.—E. S. A.

"The Science of Road Making." By J. W. Green and C. L. Ridley.

London: Crosby Lockwood & Son. Price 10*s.* 6*d.* net.

WHILE we fully realise the desirability of conciseness in technical books, we feel that the authors of this volume have attempted too much in compressing into 133 pages, with large type and ample margins, "a scientific and practical treatise dealing with road construction in its most modern forms," which the title page tells us is the scope of the work. All methods of construction and materials are dealt with, but, certainly in the case of concrete roads, too briefly to be of real value to the reader. Besides two brief suggested specifications, the concrete road is covered in about 10 pages. Thus the information is in the form of general statements which make it necessary for the reader to seek elsewhere for the details. The result is such sentences as the following: " For foundation work it is only necessary that the aggregate should be as strong in compression as the concrete itself "; surely this needs further amplification to make it understandable to the reader? We are told that a dense concrete is necessary, but an explanation of the principles of grading seems to have been omitted. The book suffers from want of detail, without which it does not seem to fulfil any useful purpose.

"The China Architect's and Builder's Compendium." 1927. Edited by J. T. W. Brooke, A.R.I.B.A., and R. W. Davis.

Shanghai: *North China Daily News & Herald*, Ltd. Price 10*s.*

THE importance of the construction industry in China is indicated by this volume, which does credit to the enterprise of its publishers. It is well printed in English throughout, and should be useful to architects, engineers and contractors in this country concerned with building operations in China. It gives full particulars of rates, water, electricity, and gas supplies, local building rules, local weights and measures, prices of material and labour, data for estimating the cost of buildings in China. The building regulations of the Shanghai Municipal Council for reinforced concrete and steel construction are given in full.

"Building Construction." By Charles F. Mitchell. Revised by George A. Mitchell, F.R.I.B.A.

London: B. T. Batsford, Ltd. Price 6*s.* 6*d.* net.

THIS volume is the tenth edition of a work that is a textbook in most building schools, and deals with elementary subjects. It may without hesitation be said to be indispensable to any student of building. It contains over 1,000 pages and 1,000 illustrations, and is one of the cheapest books published in view not only of its size but what is more important the value of its contents.

Questions and Answers relating to Reinforced Concrete.

Readers are cordially invited to send in questions relating to concrete. These questions will be replied to by an expert, and, as far as possible, answered at once direct and subsequently published where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—Ed.

Proofing Concrete Floors.

Question.—I would be very much obliged if you could tell me of any substance, either to mix in a concrete plaster or to apply to a concrete surface, that would render concrete impervious to oil and other such foreign matters.

I am building a pumping station the floor of which is of reinforced concrete; underneath is the pump well, and I am very anxious that the floor of the pump house be impervious to oil, etc., as nothing looks worse in an engine room than a dirty stained floor, which is often the case after the machinery has been dismantled a few times. Out here it is almost impossible to get a good tile; and quite impossible to get tiles well laid. Consequently I should be pleased to hear if you know of any way of treating concrete so that it becomes hard and non-porous, and at the same time not too smooth and slippery.

Tientsin. J. L.

Answer.—The usual method of making concrete impervious to oil is to treat it with silicate of soda. The method is to apply a solution of silicate of soda diluted with 4 parts of water over the face of the concrete, after it has hardened, with a brush or broom. It is necessary to brush it continuously over the surface for several minutes to obtain an even penetration. This application should be allowed to dry, and 24 hours later a second application given. After a lapse of another 24 hours the same treatment is applied again. Thus there are three separate applications of the solution with intervals of 24 hours.

It might also be advisable to use a carborundum surface in order to get a non-slippery floor. This would also darken down the concrete and lessen discoloration caused by oil. The carborundum powder is sprinkled through a sieve on to the wet concrete using between 1 and 2 lbs. of carborundum powder per square yard of concrete according to the degree of non-slipperiness required. The powder is lightly rolled or pressed into the surface of the concrete, taking care not to force it below the surface.

There is, so far as we know, no method whatever of preventing concrete from becoming discoloured if oil is allowed to come in contact with it.

Water Tanks.

Question.—In the last paragraph of Mr. Leslie Turner's article in the June number of Concrete and Constructional Engineering he refers to a reinforced concrete tank the depth of which is greater than the breadth. Is it allowable to design the smaller sides of such a tank as cantilevers, considering that the maximum bending moment will possibly be in the horizontal span?

Can you refer me to any literature dealing with the stresses in slabs supported or fixed on three sides?

C. R. K.

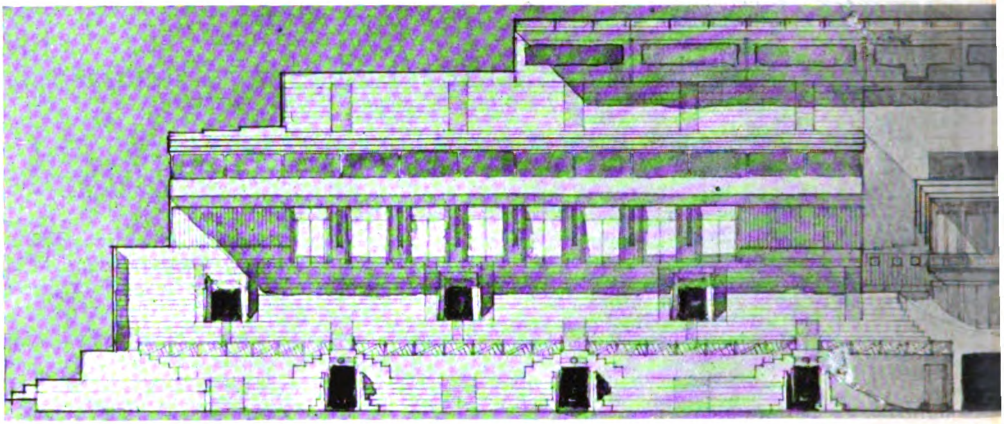
Stockton-on-Tees.

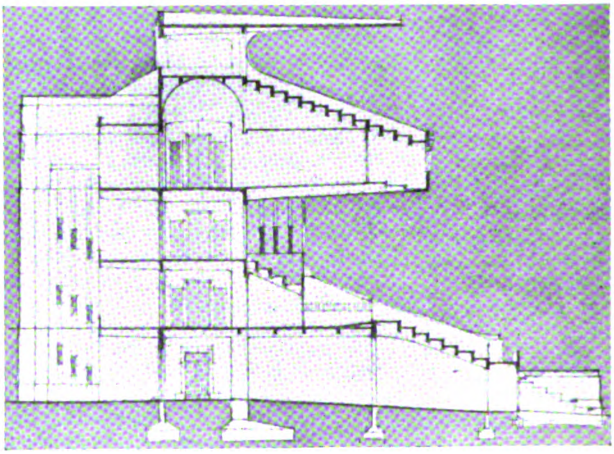
Answer.—With regard to the first point, it is not allowable to design walls the lengths of which are less than their heights, wholly as cantilevers. Near the base, however, and particularly in the middle between the corners of the tank, a certain amount of cantilevering action will take place. The balance of the load will be carried by spanning horizontally between the corners, and particularly by the fixing moments at the corners.

The design referred to on page 389 was prepared for general application and to cover all cases within the limits specified. The full amount of vertical (or cantilever) reinforcement has therefore been retained, although the crossbars and corner bars in this particular case really carry a good proportion of the load and were inserted for that purpose.

We regret we cannot refer our correspondent to any literature dealing fully and exclusively with the matter he requires, although the subject of relative deflections is usually considered in modern textbooks on concrete and elastic structures.

L. T.





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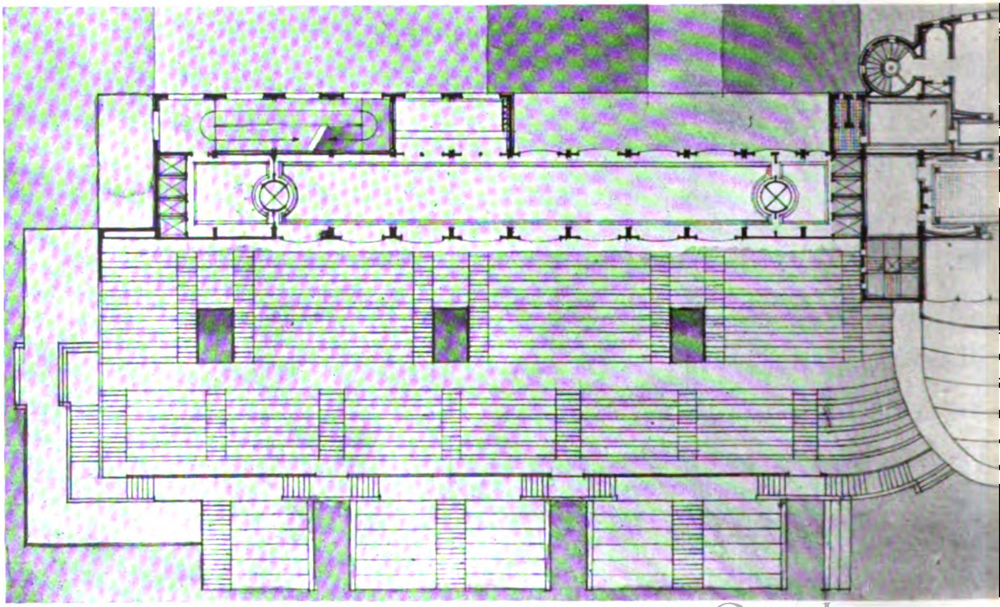

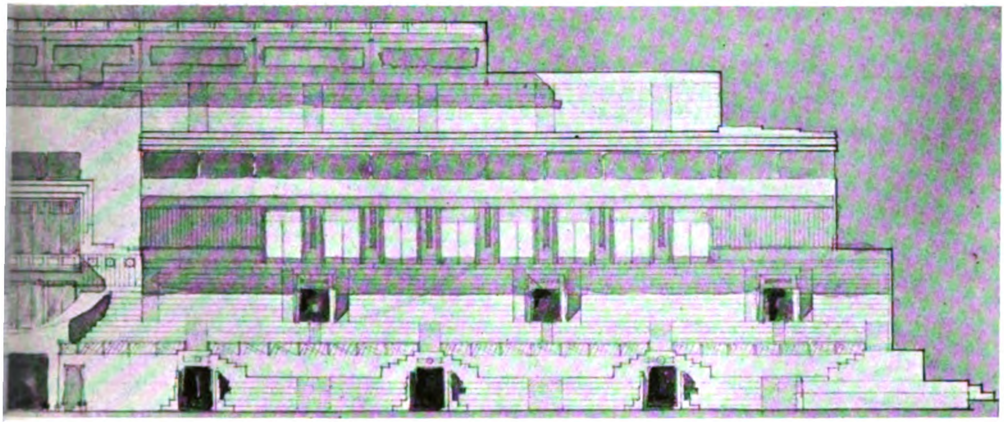

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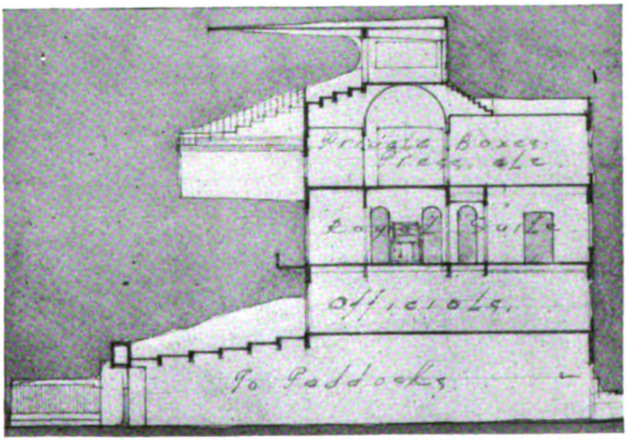
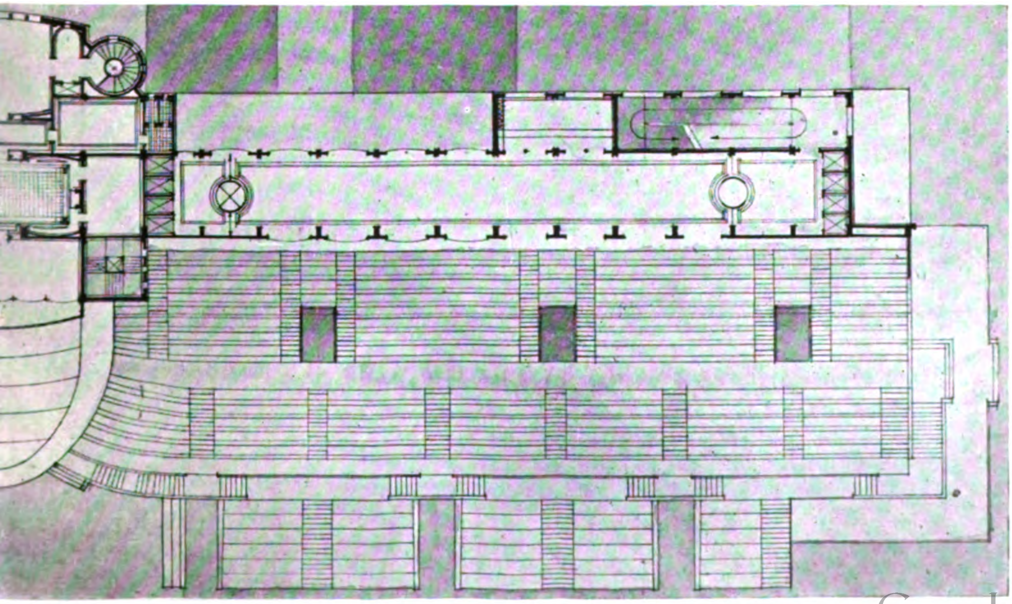
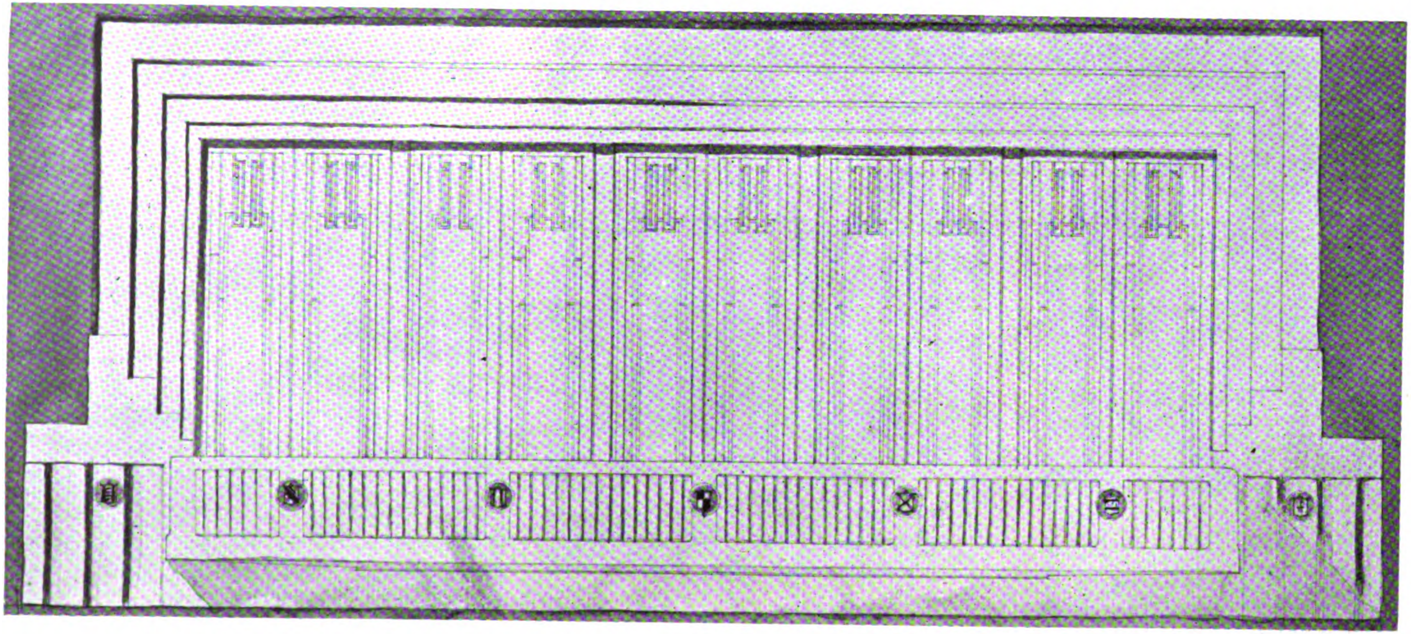




"Concrete and Constructional Engineering" Prize Design.



REINFORCED CONCRETE GRAND STAND FOR A RACECOURSE:
Detail of Royal Box.
Design placed second. By Mr. B. M. Johns. (*See pp.* 546–7.)

Reinforced Concrete Churches in France.

Church at Montmagny.

Messrs. A. & G. Perret, the well-known French architects, who specialise in the design of reinforced concrete structures, have just completed another remarkable church at Montmagny, near Paris. As will be seen from the illustrations, they have adopted the same ideas of very large window areas filled in with a pattern carried out in pre-cast concrete as in the case of the church at Raincy, designed by the same architects and illustrated in our number for January, 1924.

This new church has a length of 118 ft. and a width of 42 ft. 8 in. by a height of 42 ft. The tower rises to a height of 104 ft. In plan, the nave is very wide—practically the whole width of the church—the two narrow aisles being about 14 ft. high only; this is shown in the interior view.

The side walls of the nave, above the aisles, each consists of four reinforced concrete columns, the spaces between which are filled with tracery work in concrete, the pattern being formed of squares, crosses, circles and triangles. These shapes are uniform in size, and by this means it was possible to use the moulds repeatedly and thus keep down the cost without producing a monotonous repetition of pattern.

It will be noted that a very effective pattern has been produced on the walls to the aisles; this has been obtained by using concrete blocks whose length is twice their height and laying them in pairs on edge and on their side alternately.

The principal roof comprises a reinforced concrete vault on which is built first a hollow-brick vault and finally a layer of cement mortar provided with expansion joints.

The total cost of the building complete, including heating apparatus, electric light fittings, altars, fonts, and furniture, was the remarkably small sum of £2,600, reckoning rate of exchange as £1 = 125 francs.

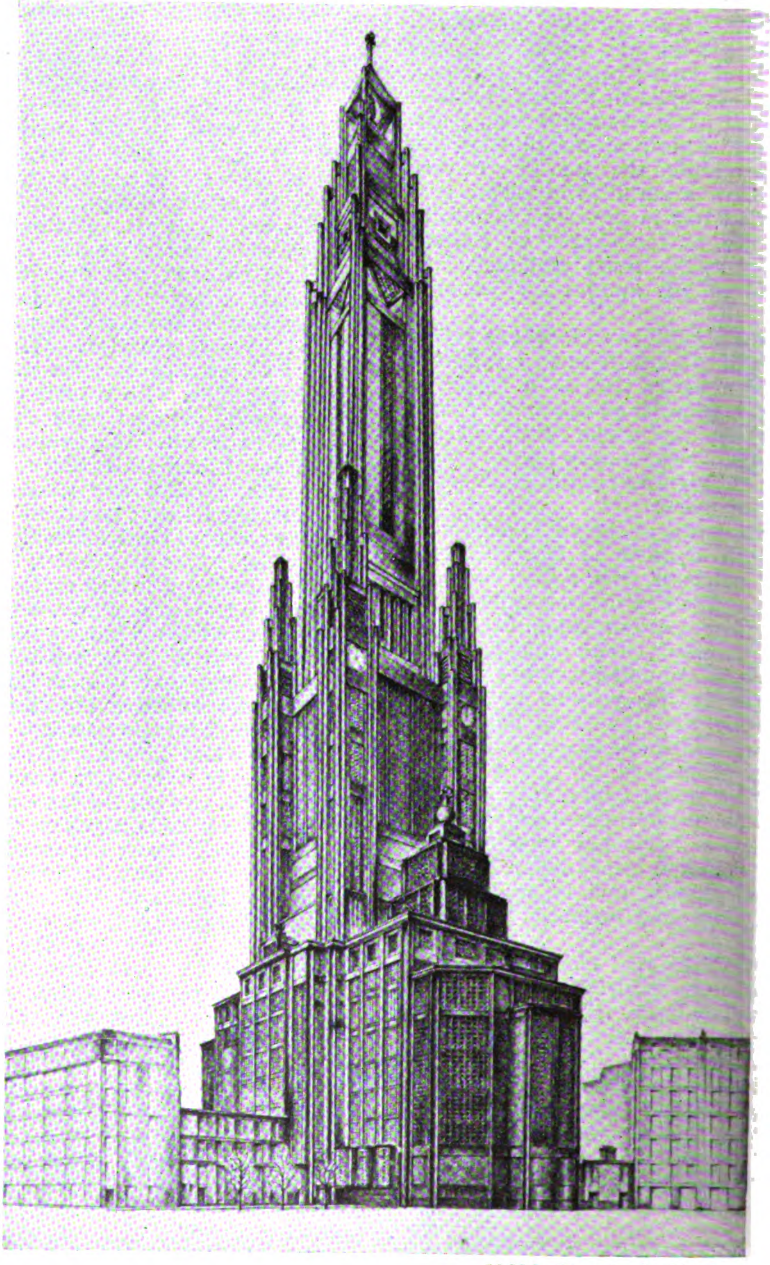
Church in Paris.

We also illustrate a design by the brothers Perret for a votive church to Joan of Arc in Paris. This illustration is given by permission of *The Manchester Guardian*, from which we take the following:

The total height of the church is about 650 ft. The tower is calculated to stand the weight of 20 tons of bells, or five tons less than the Kremlin. An organ of 50 stops is planned for the church. The lower tier of the church is largely composed of glass set in concrete tracery of severely geometrical design. There, however, the severity ends. Each enormous window, which is rectangular, is divided into three sections, and over the three sections an enormous, high-shouldered cross appears in the glass, being merely outlined by its colouring. Within the cross are pictorial designs, the rest of the space being filled with a blaze of blues, reds, purples, outlined with little pinpoints of light, after the manner of the twelfth and thirteenth century windows at Chartres. Unlike any windows that have gone before, the glass itself contains the other coloured glass which gives point to the whole. The second tier, the comparative slimness of which gives grace to the whole, is treated similarly, being made of enormous atelier windows filled with coloured glass. So important is the glass in the building that it is made double with a space between and small iron ladders which facilitate its cleaning. On the top of the third longer and still more slender tier is a concrete canopy surmounted by a cross of the same material. The canopy contains a golden statue of the saint who is being commemorated.

Unlike Norman architecture, it is all exceedingly light and slender; unlike Gothic, it dispenses entirely with the flying buttress, the strength of the concrete comparing to its great advantage with that of pieces of stone mortared together.

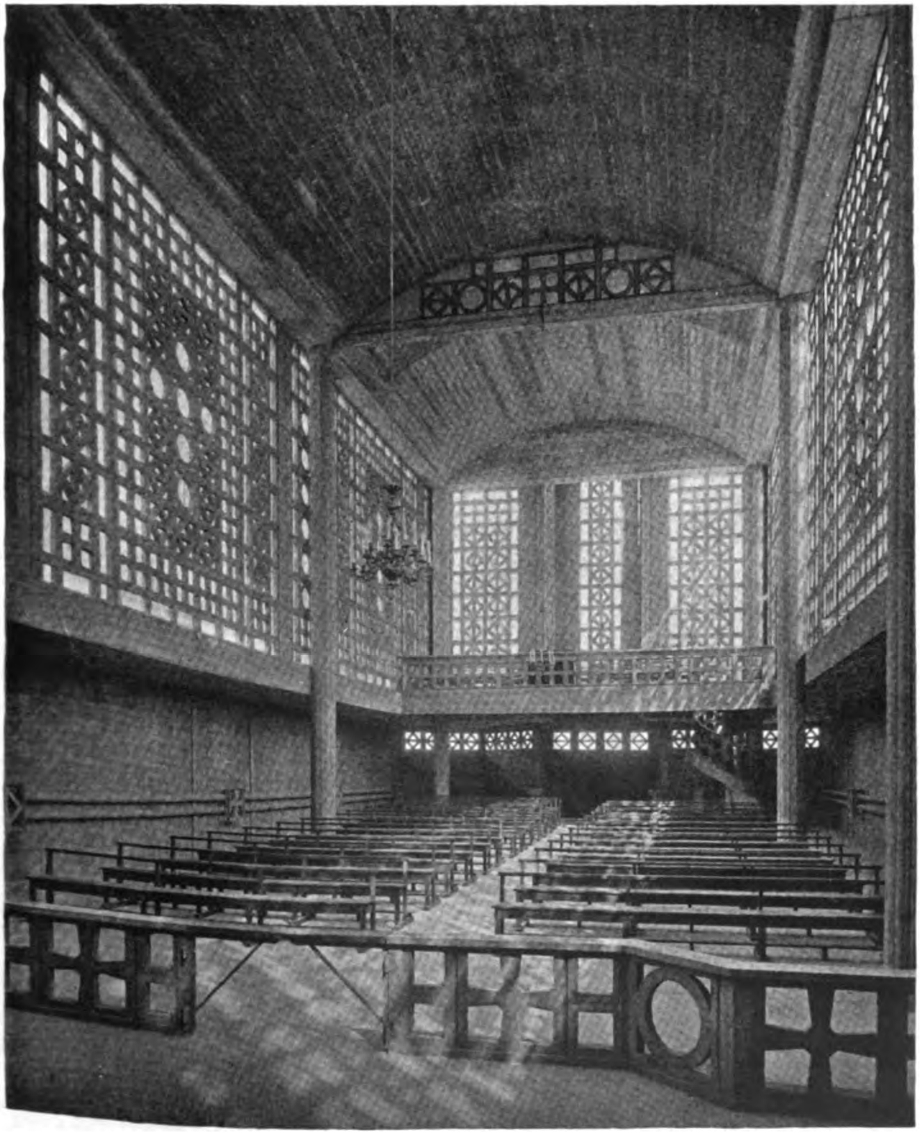
While any deviation from an established tradition is apt to shock not only the eye but the feelings, the use of concrete, with its greater strength, its adaptation to modern needs, and, also most important, the fact that it costs about a third of the ordinary stonework, is an honourable attempt to express a feeling common to the fifteenth and the twentieth century alike, in a language which is alive. The present need for housing large congregations demands a huge building with corresponding height and light. An atmosphere of tranquillity and abstrac-



[MM. Perret, Architects.

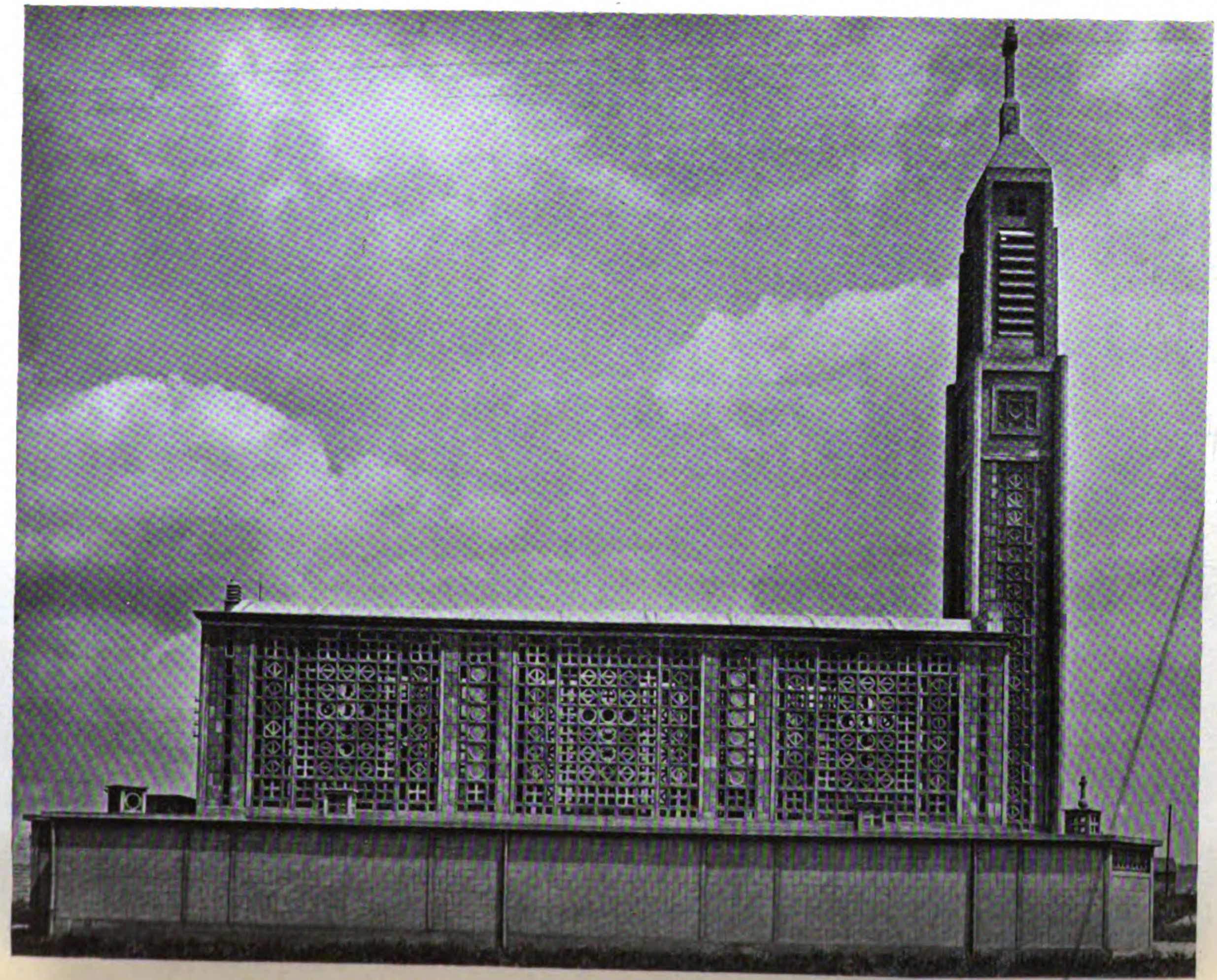
Design for Reinforced Concrete Church in Paris.

tion is necessary, which can lift the worshipper out of the daily rut. So strong is the force of tradition that it too often becomes an end in itself, and the reason for which it existed dies proportionally. The concrete church, with all its qualities together, some so-called beautiful, some so-called ugly, is a very definite expression of the day, a language which even the simplest can understand and which gives sudden life to ideas that have long been slumbering. Combined, as it is in M. Perret's churches, with the utmost simplicity of line and the extreme beauty of the glass, it may be that a language is slowly being evolved which will be as vivid to the modern worshipper as the tradition of St. Louis was to St. Joan herself.

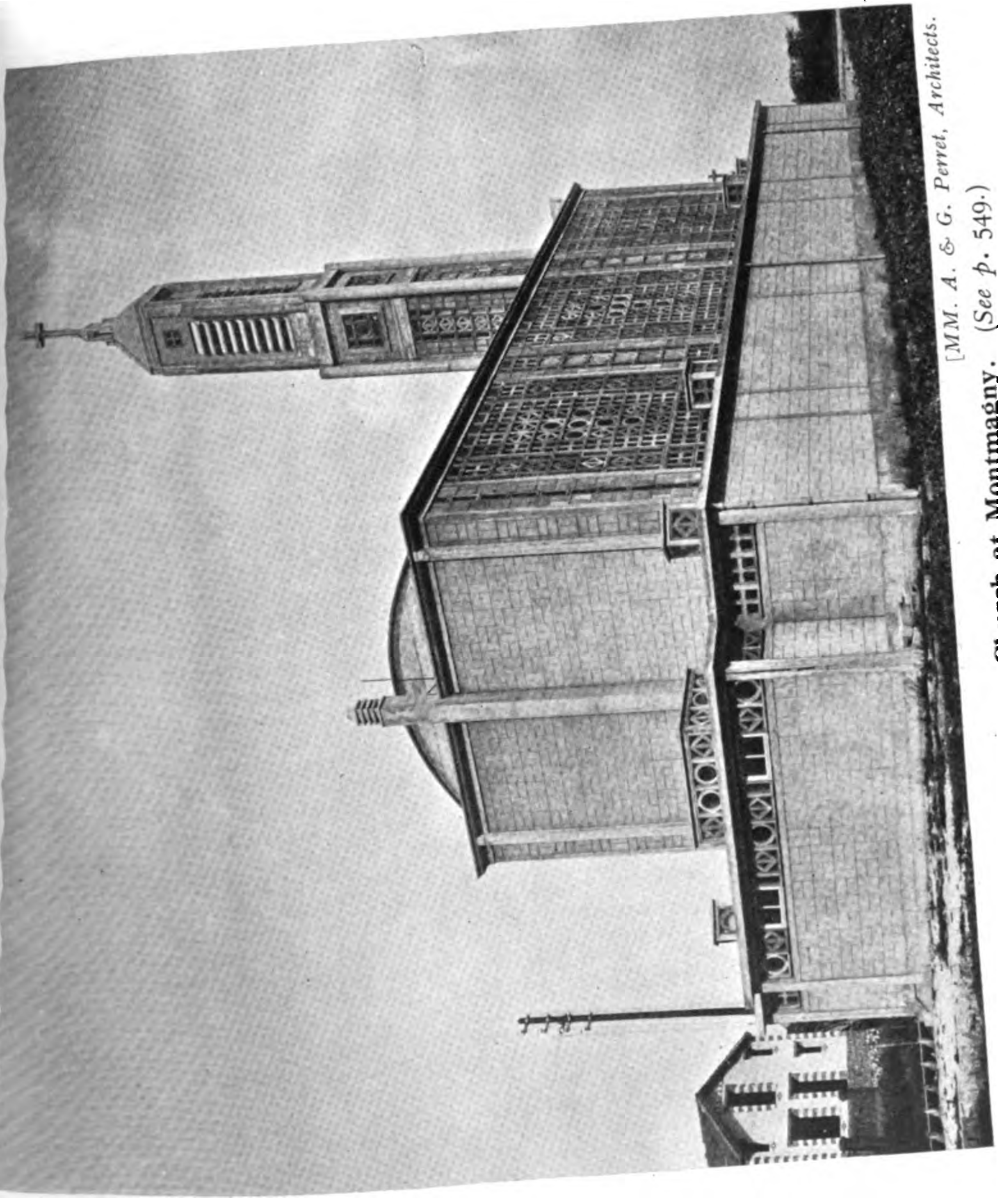


[*MM. A. & G. Perret, Architects.*

Reinforced Concrete Church at Montmagny.



Reinforced Concrete Church at Montmagny. [MM. A. & G. Perret, Architects. (See p. 549.)



[MM. A. & G. Perret, Architects.

Reinforced Concrete Church at Montmagny. (*See p.* 549.)

Mild Steel versus High-Tensile Steel.

THE publication in the May issue of this journal of correspondence on the question of the relative value of mild steel and high-tensile steel stated the case for mild steel. The following statement of the case for high-tensile steel, particularly in regard to road reinforcement, has been sent to us by Mr. J. F. Butler, A.C.G.I., A.M.Inst.C.E., M.Struct.E :—

In the first place, states our correspondent, it might be pointed out that there is an unfortunate looseness in the title " Mild v. High-Tensile Steel " and also in the corresponding wording in the article. This may be due to lack of information in regard to the material of which high-tensile steel is made. The high-tensile steel referred to in the article, as mentioned in some places directly and in others by inference, is drawn wire, and drawn wire is itself mild steel. Presumably the article is intended to deal with the value of rolled steel as compared with drawn wire, but to state it as " mild steel as compared with high-tensile steel " is to give at the outset a misleading impression that drawn wire is not mild steel but is a material other than mild steel and may have for that reason certain disadvantages, whereas the fact is that drawn steel, as used for road reinforcement, is actually mild steel, and in order to enable it to be successfully drawn it must be mild steel of very good quality.

By the very nature of its manufacture drawn wire is a material perfectly accurate in section ; No. 5 gauge wire, for instance, is 0·212 in. diameter, but may vary between 0·211 and 0·213 in., an extreme variation of 1 per cent. Rolled rods, on the other hand, may vary as much as 20 per cent. In the small sizes used for road work the ordinary rolling margin of 2½ per cent. used for diameters of ⅝ in. and upwards does not apply, and a variation of 10 per cent. in diameter, which is rather more than 20 per cent. in cross section, is quite common. Thus a tensile reinforcement of rolled steel which is nominally a certain size may be 20 per cent. less, and the strength correspondingly 20 per cent. less.

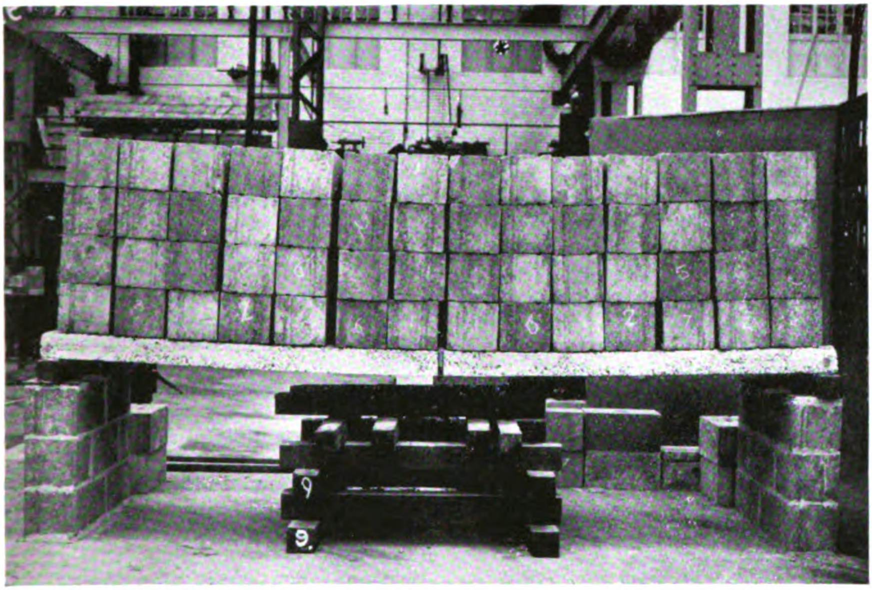
The correspondence in question refers to a preference shown by the Ministry of Transport in favour of high-tensile steel, but the specification quoted in the article does not appear to show any preference. On the contrary, it shows a preference for rolled steel the value of which is allowed to be gauged by one-half the strength at the minimum yield point, whereas the value of high-tensile steel is allowed to be gauged by only one-third the strength at the yield point. For equal strength the ratio to the yield point should surely be the same in each case, and if half is allowed to rolled rods, half (instead of one-third) should be allowed to drawn wire.

The correspondence raises the question of cracks. Almost its whole argument against high-tensile reinforcement is on this question of cracks, but without reference to or information on the one important point, which is the whole point, namely as to when the cracking in the concrete commences to have a practical significance ; or, in other words, What is a serious crack and when does it take place ? The answer to this is that a serious crack is a crack which is sufficiently large to allow access of moisture and air sufficient to cause rusting of the reinforcement, and the stress in the steel at which this takes place is considerably higher than the working stresses referred to by the Ministry in their specification.

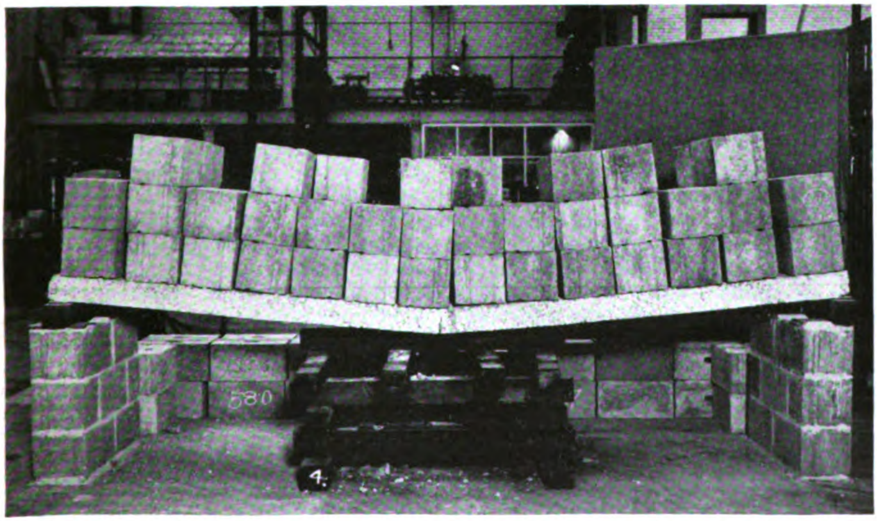
As regards the statement that a high-tensile steel only begins to be of greater service than rolled steel at stresses at which the concrete surrounding the steel is cracked, it is a fact that in all reinforced concrete structures the tensile steel hardly operates at all until after the concrete is cracked. Concrete has a tensile strength of about 200 lbs. per sq. in., and this stress is reached in the concrete when the stress in the adjoining steel is 3,000 lbs. per sq. in. It cannot be seriously suggested that 3,000 lbs. per sq. in. is the maximum stress to which the steel can be usefully employed, for this in other words would mean that the steel in reinforced concrete construction is practically useless. Such a theory would condemn every reinforced concrete structure that has ever been designed and it would put a stop to all serious reinforced concrete construction.

Fortunately there is a flaw in the argument, and the flaw is this : That although the concrete surrounding the steel is cracked almost before any stress comes on the steel at all, and such crack-

Tests on Reinforced Slabs.



Slab Reinforced with Drawn Wire Fabric loaded with 112 blocks ; Slab broke with load of 116 blocks.



Similar Slab Reinforced with equal weight of Rolled Steel Rods : Slab broke under 71 blocks.

ing is distributed quite freely along the length of concrete surrounding any steel bar in tension, the cracking is so minute that it has no practical significance and is of no importance. As the stress in the steel increases the cracks open out, but even at high stresses in the steel they are of such small dimension that it is difficult to see them, and they are not of any practical significance. When the stress in the rolled steel approaches the yield point the cracking becomes serious. At the yield point the steel stretches considerably and the slab is permanently ruined, but at a corresponding stress in drawn wire the steel is only half-way to the yield point, the cracks remain insignificant and almost invisible, and the slab continues to carry its load without being in any way permanently damaged. If the load is removed, as is happening all the time under road traffic, the steel goes back to its original length and the cracks close up perfectly tight. As regards the magnitude of such cracks, if we assume that the steel is stressed to, say, 40,000 lbs. per sq. in., that this occurs over a length of 12 in., and the whole extension is concentrated in one crack, the width of that crack will be less than one-sixtieth of an inch ; but actually the extension is not concentrated in this way, but is distributed through a number of cracks, some visible and others invisible.

The correspondence states that several roads reinforced with rolled steel are standing up against heavy traffic, but this does not prove that rolled steel is better than drawn steel. It does not prove anything. If the case were to depend on the area of satisfactory roads reinforced with drawn steel as compared with the area reinforced with rolled steel the figures would be hundreds to one in favour of drawn steel, this being the original reinforcement used for road reinforcement and the reinforcement which has been used for the bulk of the work.

On the question of bond or adhesion between the steel and the concrete, it is argued that because the higher strength allows a smaller section of drawn wire to be used than rolled rods, so that there is less surface area for adhesion with the concrete, there is a greater liability for the drawn steel to slip. In actual practice this does not hold good. It is the custom to use the drawn wire in the form of a machine-made mesh and small diameters of wire can be used, these being spaced generally 3 in. apart. When rolled steel is used it is generally in the form of rods that are laid or made up into some form of mesh at the site, and the wires are of much larger section than the drawn wire and are spaced farther apart; this wider spacing reduces the ratio of circumference to cross-section and reduces the amount of surface available for adhesion, with the result that so far from the drawn wire having a smaller surface area for adhesion it actually has about 15 per cent. larger area, in spite of the fact that a smaller cross-section is used. An additional feature in regard to adhesion is that the drawn wire is frequently used in the form of a fabric with transverse wires welded to the longitudinal wires at intervals of 12 in., providing an additional anchorage into the concrete.

This question of adhesion is not in any case of much importance in road work because the changes in stress in the steel take place over a sufficient length of steel to allow very ample area for adhesion. The conditions are not at all like the conditions in the beams in a building, where the steel bars are of very much larger diameters and where the ratio of circumference to cross-section is very much less than in the small sizes of wire that are used in road work. The length of 1-in. bar, for instance, required so that the adhesion will equal the tensile strength (at 16,000 lbs. per sq. in.) is 40 in., whereas the length of 5-gauge wire required so that the adhesion will equal the tensile strength (at 24,000 lb. per sq. in.) is less than 13 in.

Whatever suggestions may be made in regard to the comparative stresses that should or should not be allowed, the fact remains that if any tests are made of concrete slabs reinforced with rolled rods and concrete slabs reinforced with drawn wire, the slabs reinforced with drawn wire will carry certainly 50 per cent. more load than the slabs reinforced with rolled rods. In view of this fact (and it is a fact that can be tested by anybody at any time, and the result will always be the same) there is something wrong with a theory advanced to show that the rolled steel is as good as the drawn steel. If the facts that are proved by the tests do not agree with the theory, it is not the tests and the practice that require alteration but it is the theory that requires to be brought into line and to correct itself. The illustrations herewith show ordinary examples of exactly similar slabs constructed at exactly the same time, reinforced with equal weights of drawn wire fabric and rolled steel rods. The drawn wire fabric carries a load more than 50 per cent. greater than that at which the rolled steel slab failed. The reinforcement in these slabs is rather more than the percentage usually employed in road work ; with a smaller percentage of reinforcement the difference would, if anything, be still greater in favour of drawn wire.

The whole question was investigated by the Concrete Institute, and tests were made in 1920, the report of the tests being as follows :—

" The test records given show that if we are content with the same factor of safety for high tensile steels, then it would be right to design (as compared with the working stress of 16,000 lbs. for mild steel) for working stresses of 22,000 lbs. per square inch for medium carbon steel and 21,500 lbs. per square inch for 'twisted' steel bars, and 25,000 lbs. per square inch for drawn steel wire of the qualities employed in these particular tests.

" As regards the question of the deflections being greater, consequently the cracks larger, the tests show that the deflections were certainly greater, because, of course, the loads sustained were bigger ; but the tests bring out quite clearly, as is shown by the photographs, that in all cases the increased stress developed in the steel did not result in larger cracks, but only in a greater number of cracks ; therefore the argument that by using a higher stress the steel would be exposed more to corrosion, falls to the ground."

The Ministry of Transport regulation is nearly in agreement with the results of the Concrete Institute tests, but does not allow as much to drawn wire as those tests would justify. Actually, from a detailed study of the figures of the Concrete Institute tests, it appears that a working stress of 28,000 lbs. in drawn wire is as safe as 16,000 lbs. in rolled rods.

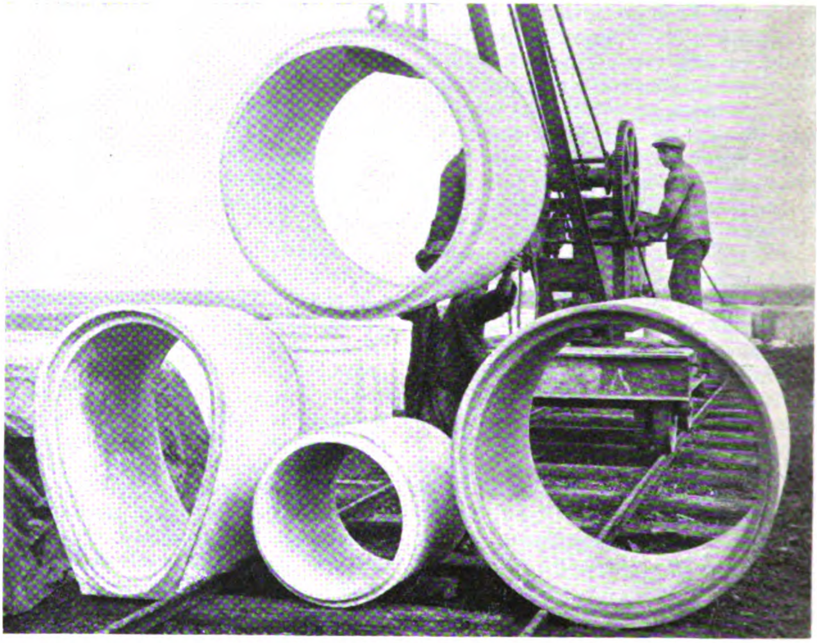
[⁂We cannot publish further correspondence on this subject.—Ed.]

Test of Reinforced Concrete Structure under Locomotive.

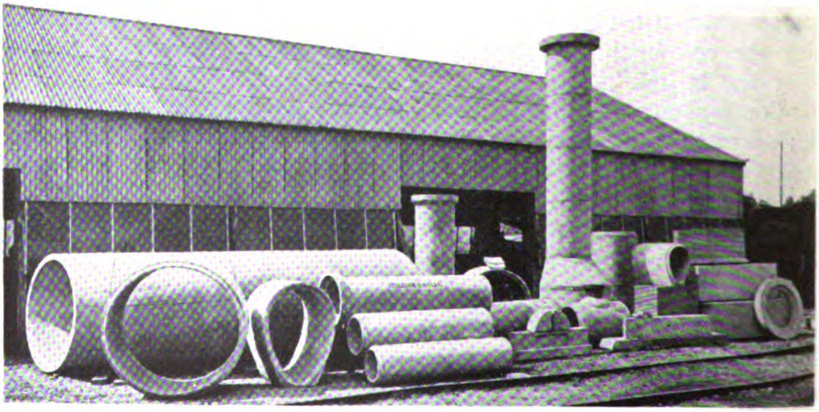
In connection with the construction of a coal-handling plant at Orléans the Compagnie du Chemin de fer de Paris à Orléans required a test of the beams crossing the coal-bunker. With this aim, an engine weighing 87 tons was run over the beams.

" Le Constructeur de Ciment Armé " recently gave a summary of these tests which showed that the maximum deflection of a rail-bearer was 1 mm. on a span of about 3 metres, i.e. a ratio of deflection to span of 1 to 3,000. No permanent deflection was registered.

The axle loads were five in number, each of about 17½ tons, and spaced at 5 ft. centres.—W. S. G.



Concrete Pipes for Sheerness Main Sewerage. Mr. F. W. I. Stanton, A.M.Inst.C.E., Consulting Engineer.



Concrete Pipes, Blocks, Kerb, Manholes and other Pre-cast Units made by Trollope & Colls, Ltd., at their Factory at Isleworth.

(*See p.* 559.)

Concrete Pipes.

A NEW department for the manufacture of concrete pipes and other pre-cast concrete units has been opened by Messrs. Trollope & Colls, Ltd., and is now in full working order. A central factory has been established at Isleworth, and already it has been found necessary to carry out extensions to cope with the increasing demand. In addition to the factory at Isleworth from which the demand in London and the Home Counties is met, the firm sets up its own plant in any district where the distance from Isleworth makes this more economical than despatching goods by road or rail.

It is, however, in pipes that the firm is specialising, and contracts already in hand or completed include concrete pipes for main drainage at Sheerness, Whitley Bay, Seaton Burn Valley, Weetslade, and Folkestone. These are made with spigot-and-socket and ogee joints, the former in 8 ft. lengths by from 18 in. to 60 in. internal diameter and the latter in lengths of 3 ft. or 6 ft. 1 in. by from 15 in. to 72 in. internal diameter.

The pipes are made with special plant and processes which includes the consolidation within the moulds by vibration. The moulds are of cast iron, machined on the working faces so that the pipes have particularly smooth surfaces and very accurate joints; we understand that on a recent contract the total "creep" was only 7½ in. in a length of 80 yds. The mix is 1 part rapid-hardening Portland cement, 1⅓ parts sand, to 2⅔ parts crushed granite. The proportion of sand is liable to slight variation according to the grading of the coarse aggregate. If so desired, ballast can be substituted for granite for the sake of economy.

We illustrate herewith some of these recent pipe contracts, and also some manholes and other pre-cast concrete products of the firm. The Folkestone contract is a typical example of a job where the pipes are made on the site, and is in connection with the construction of the first section of the high-level intercepting sewer, which is designed to intercept the drainage from some of the higher districts on the outskirts of Folkestone.

The sewer, which will deal with a maximum flow of 30,000 gallons per minute, consists of reinforced concrete pipes, 4 ft. 6 in. in diameter by 3 ft. long, by 3 in. thick, doubly reinforced, which when laid are surrounded by a further 6 in. of concrete. The reinforcement

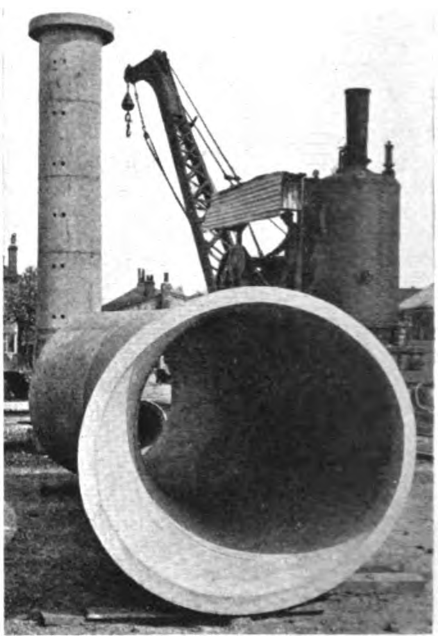
Concrete Pipes made at Whitley Bay for the Whitley & Monkseaton U.D.C. Mr. A. J. Rousell, A.M.Inst.C.E., Surveyor to the U.D.C.

consists of unwound cable dealt with on the firm's patent machines. To assemble the reinforcement, a number of cable drums are mounted on stands, and from these the cable is wound around a cylindrical drum of the required diameter, spacing wires are introduced, and the whole cage is wired up and taken off the drum.

The moulds are assembled and the reinforcement cage placed inside. The moulds are mounted on 2 ft. gauge bogies and wheeled on the vibrating table, the bogie being anchored to the platform by tie rods. The concrete is mixed in a ½-yd. mechanical mixer, and tipped into an elevating hopper; the hopper is then hoisted to a platform above the vibrating table, and it automatically discharges the concrete through a chute into the top of the mould, while the table is vibrating. The mixing and shaking plant is one mechanical unit driven by a 12 h.-p. motor.

When the pouring of the pipe is completed, it is wheeled into a maturing chamber, which is kept at an even temperature. The pipes are matured for twelve hours and the moulds are then struck, the pipes being sufficiently hard for preliminary handling. These pipes have to withstand a concentrated load of 4,000 lbs. per 3 ft. pipe and also an internal pressure of 25 lbs. per sq. in. Loading tests have been carried out and the pipes have satisfactorily withstood much greater loads.

The moulds consist of two cast-iron end formers and sheet steel inner and outer shells. The rapid-hardening cement and the rapid maturing process enable each mould to be used once daily, and an output of fourteen pipes per day, equivalent to 42 ft. run of sewer, is maintained, with the use of fourteen moulds.



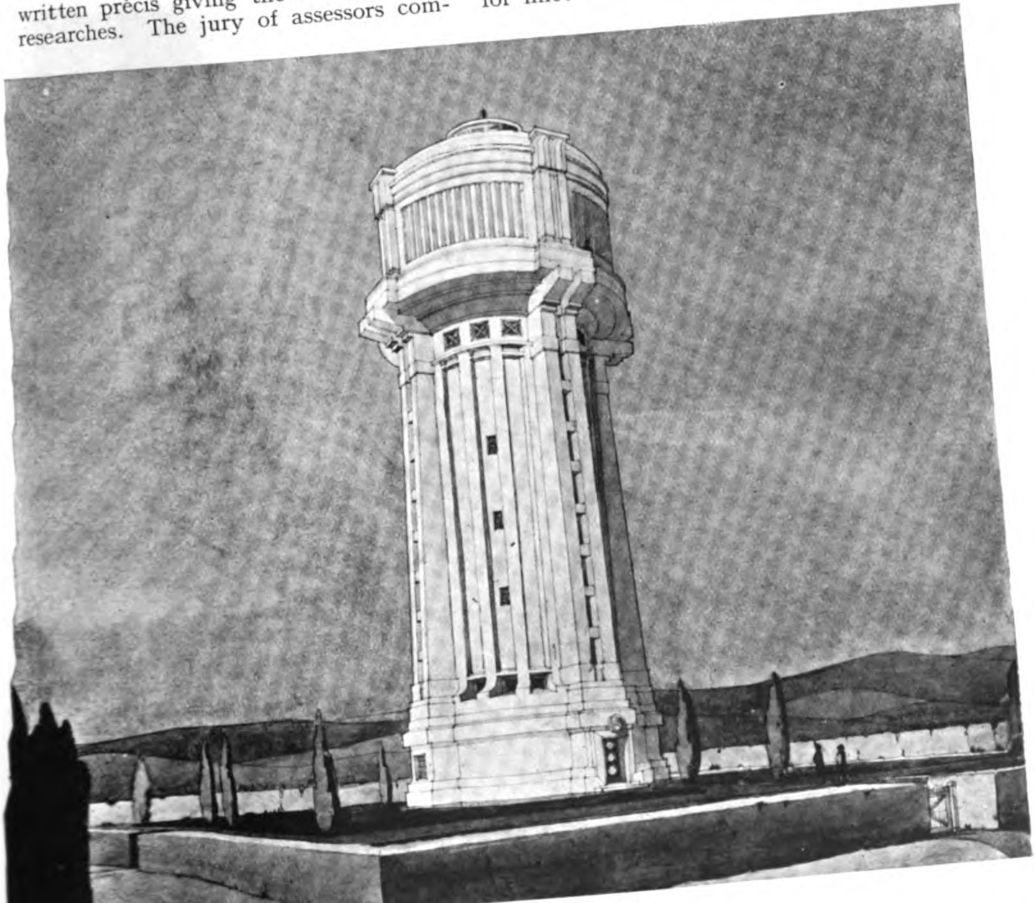
Concrete Pipe Bends (54 in. diameter) for Folkestone Corporation, and a Concrete Manhole. Mr. A. E. Nichols, M.Inst.C.E., Borough Engineer and Surveyor.

The scheme was designed and is being carried out under the supervision of the Borough Engineer, Mr. A. E. Nichols, M.Inst.C.E.

Designs for Water Towers.

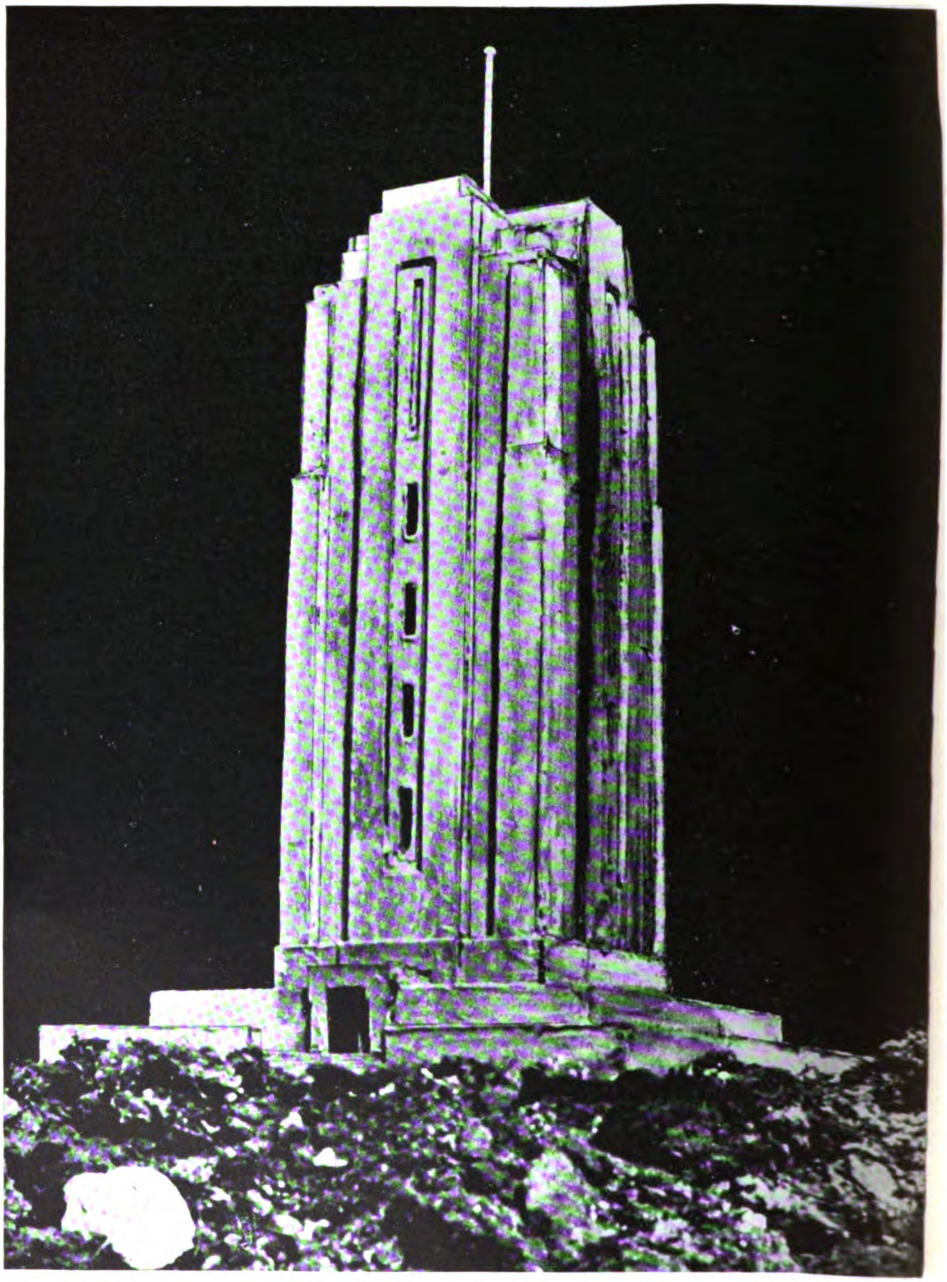
We illustrate on pp. 561–3 the designs placed first, second and third in the Brenforce Travelling Scholarship, 1927, awarded by the Institution of Structural Engineers. The Scholarship is of the value of £300, provided by the British Reinforced Concrete Engineering Co., Ltd., and is awarded every three years. The successful candidate is required to travel for forty-two days on the Continent of Europe, outside the United Kingdom, in order to study the development of æsthetic design in concrete and reinforced concrete buildings, and upon his return he is asked to submit a type-written précis giving the results of his researches. The jury of assessors comprised Mr. H. J. Deane (President of the Institution), Mr. A. Trystan Edwards, Professor J. Husband, Mr. J. Mitchell Moncrieff and Mr. H. D. Searles-Wood.

The subject chosen was a water-tower in reinforced concrete, to be erected in an exposed commanding position on an eminence in moorland country, and provided with a balcony open to the public. The tank was to hold 250,000 gallons of water, and was to be supported at a height of 100 ft. above ground. Easy access was to be provided to the roof of the water tank for purposes of inspection, while arrangements were also to be made for inlet and overflow.



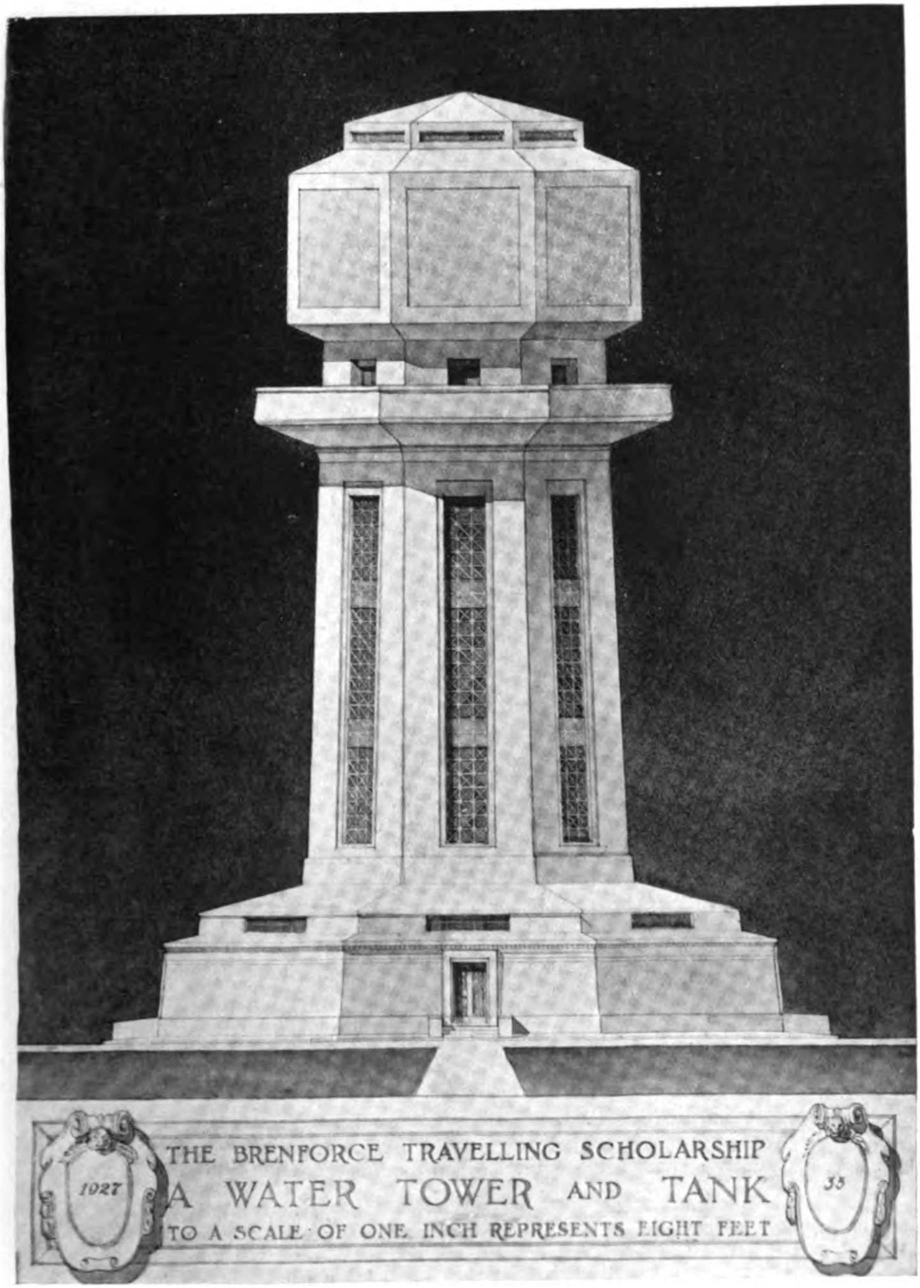
Winning Design.

By Mr. J. Blacket (Newport).



Reinforced Concrete Water Tower.

DESIGN PLACED SECOND: BY MR. S. H. SUTHERS. (*See p.* 561.)


THE BRENFORCE TRAVELLING SCHOLARSHIP
A WATER TOWER AND TANK
TO A SCALE OF ONE INCH REPRESENTS EIGHT FEET
1927
35

Reinforced Concrete Water Tower.

Design placed Third: By Mr. E. Williams. (*See p.* 561.)

Joints in Concrete Roads.

(*Continued.*)

By R. A. B. SMITH, A.M.Inst.C.E., A.C.G.I.

DUMMY JOINTS

ALTHOUGH little use has been made of the "dummy" joint, its potentialities have often been discussed by engineers. The idea is that a continuously-constructed road will remain for a considerable period without cracks, but that eventually these will occur; if, however, it is possible to induce these cracks to follow certain definite straight lines, then maintenance is as easy as where definite straight expansion joints have been employed. It is also thought that a combination of "dummy" joints and expansion joints would in certain cases be of advantage by allowing increased speed for the construction gang. Assuming that 60 ft. has been accepted as the limit for a panel, then by employing, say, two "dummy" joints in a 90 ft. panel the safety factor is still kept.

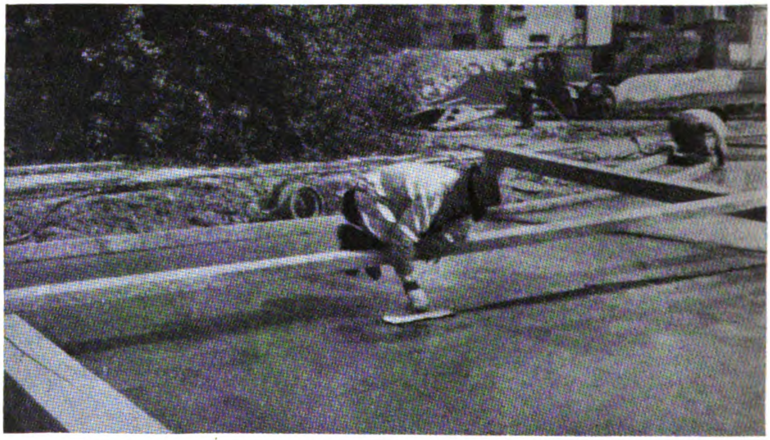


Fig. 1.—Placing Pre-cast Joint Filler with Wood Float.

The City Engineer of Seattle has used "dummy" joints extensively, owing to the fact that the price of steel was high, and the roads are constructed in small bays without reinforcement. In the first instance he constructed panels 20 ft. and 30 ft. long, but as cracks developed in the 30-ft. panels only he now places "dummy" joints 20 ft. apart.

When constructing a road 30 ft. wide, the whole width was concreted in one operation, whilst the centre joint was made 2 in. deep by driving a tee-iron 6 ft. long into the concrete with a sledge-hammer. When the concrete was 80 ft. wide a pre-cast filler was pressed into the groove with

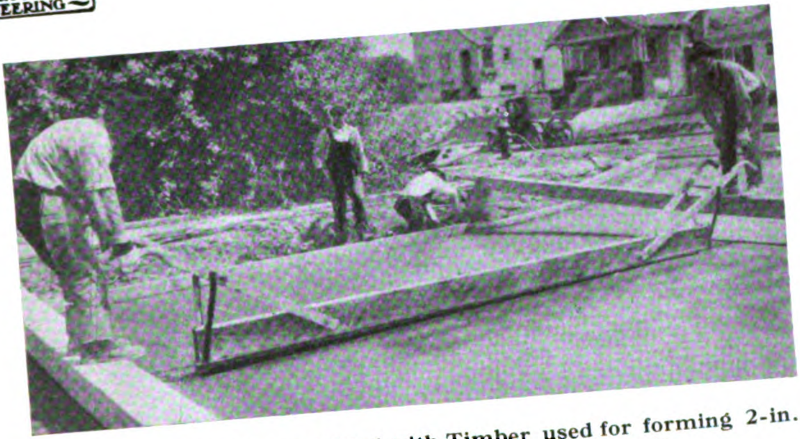


Fig. 2.—Steel T-Bar weighted with Timber used for forming 2-in. groove for Joint Filler in Finished Concrete.

a wood float and the two arrises rounded with an edging tool (*Fig.* 1). For dummy transverse joints the tee-iron may be fixed to a piece of timber and pressed down by a man at each end (*Fig.* 2); in this case the tee-iron should be shaped to the camber of the road.

It is of importance to realise that when the filler is poured flush with the surface, or when the pre-cast filler is being pressed down to its finished level between rounded arrises, it is essential that all dust or other foreign matter should be blown out of the joint so that the filler gets a direct knit with the concrete; it will be found that when this little attention is paid the filler is far less liable to be picked up by traffic.

Diagonal and Staggered Joints.

One cannot discuss the subject of joints without attempting to thrash out the question of diagonal and staggered joints.

Judging from results obtained, the joints of a road may be at an angle of from 10 deg. to 30 deg. from the right angle when the road is constructed full width at a time; that is, in ordinary continuous con-

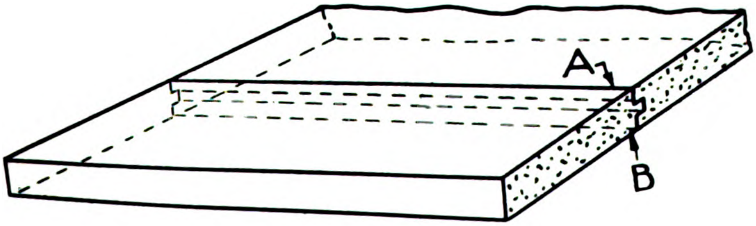


Fig. 3.

struction or alternate-bay construction. The reason this method meets with a certain amount of success in these two cases is that the weak angles are at the edge of the road where traffic is generally slow, but to introduce this weak angle into any other part of the surface of the road would be to risk trouble. It is believed by the writer that the only reason why there is only one corner break on the concrete section of the north side of the Thames Embankment is that the longitudinal joint is a tongue-and-groove one whereby the load on the weak angle is partially transmitted to the adjacent strong one, i.e., the load at A is partially carried by B and the slab is strengthened in its weakest place by the interlocking (*Fig.* 3).

When the diagonal joint is adopted in alternate bay construction it is essential that the tamping should be parallel to the sides of the road and not at right angles to the diagonal joints. When the latter method is adopted (and at first sight it does not appear wrong) a depression is formed in the middle of the panel thus causing the formation of a wavy road; if tamping at right angles to the diagonal joints is desired, the tamper must be correctly cambered even though the camber required be only ¼ in. or less.

Both in England and in Ireland the writer has seen transverse joints

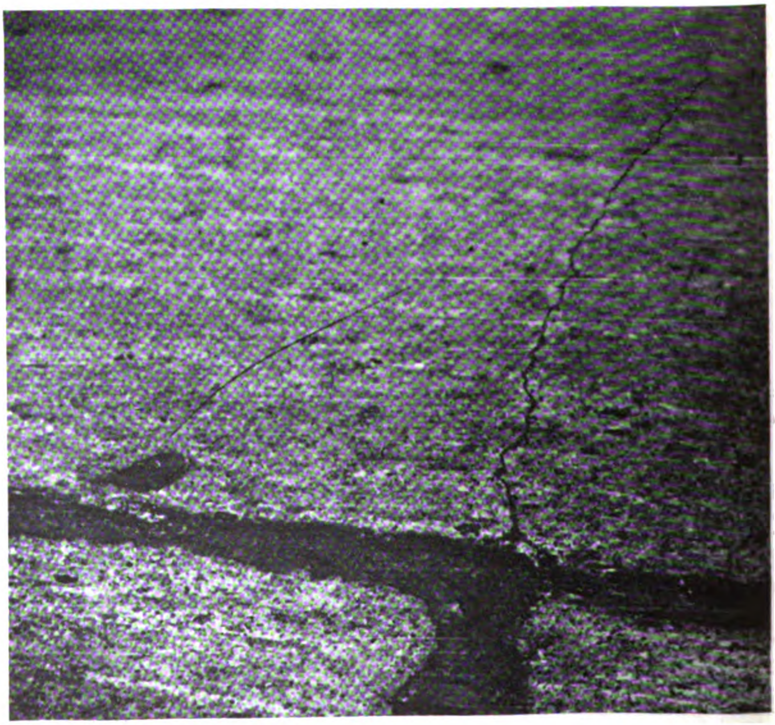


Fig. 4.—Showing Crack in Panel opposite Diagonal Staggered Joint.

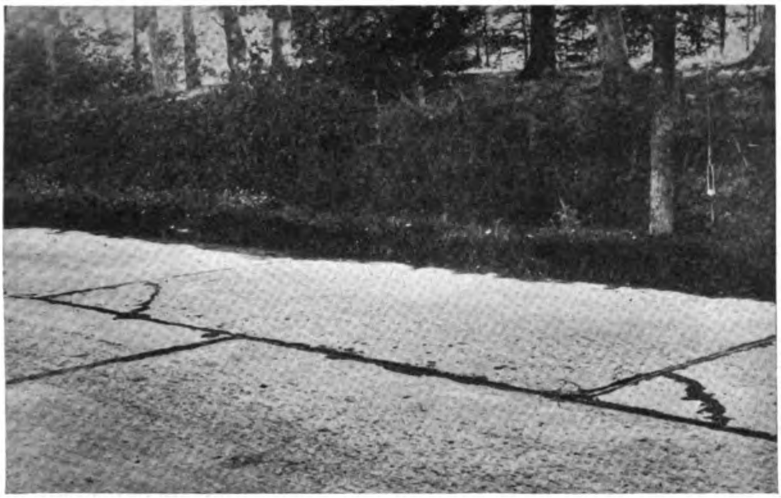


Fig. 5.—Corner Breaks, showing Weakness of Joints at Acute Angles.

carried only half way across the road. This leads to an extension of the joint by a crack across to the edge of the road, and beyond fixing the points at which the cracks shall occur one can see nothing to say in favour of such a method. When the road is laid in two or three strips then the diagonal joint may be used in conjunction with the tongue-and-groove longitudinal joint, and even then the joint must run straight across the road. If the joint is staggered across the road cracks will develop as shown, and gradually split the opposite panel (*Fig.* 4), although it is possible this may not apply to roads in very short panels.

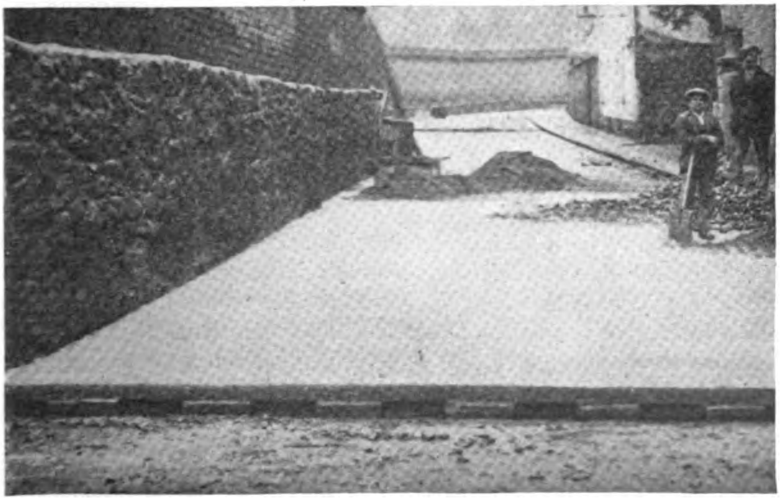


Fig. 6.—A Type of Interlocking Joint.

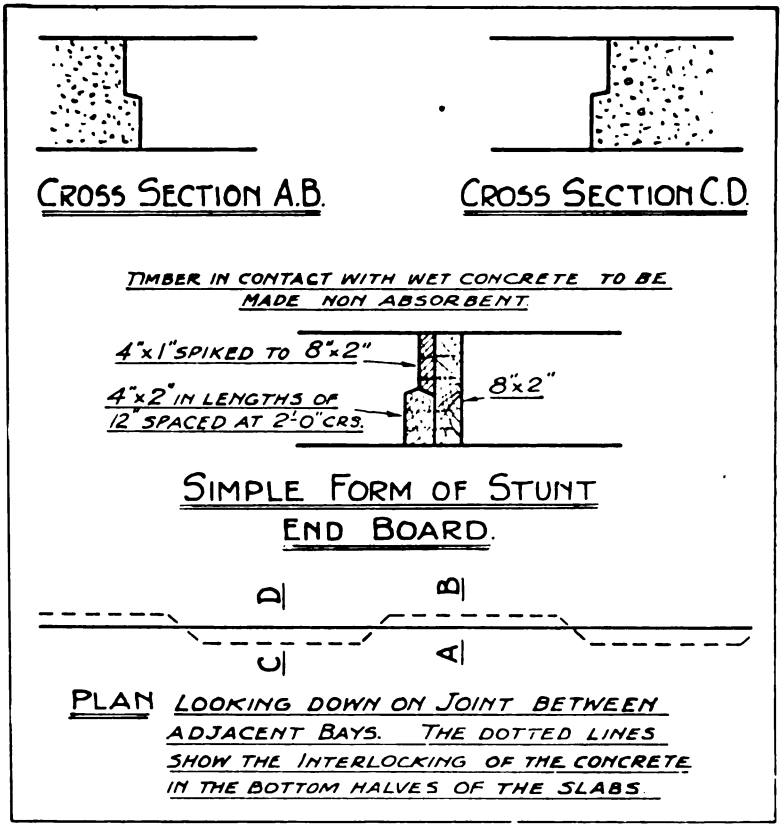

CROSS SECTION A.B.
CROSS SECTION C.D.
TIMBER IN CONTACT WITH WET CONCRETE TO BE MADE NON ABSORBENT.
4"x1" SPIKED TO 8"x2"
4"x2" IN LENGTHS OF 12" SPACED AT 2'-0" CRS.
8"x2"
SIMPLE FORM OF STUNT END BOARD.
A
B
C
D
PLAN LOOKING DOWN ON JOINT BETWEEN ADJACENT BAYS. THE DOTTED LINES SHOW THE INTERLOCKING OF THE CONCRETE IN THE BOTTOM HALVES OF THE SLABS.

Fig. 7.—A Type of Interlocking Joint.

To simplify the progress of the work it is advisable to allow the gang latitude in the length of the panel, specifying a length of, say, " from 50 to 60 ft." This means that the panels on the return journey must be of the same lengths when a butt or tongue-and-groove joint is used, but they need not coincide if bitumen the full depth of the longitudinal joint separates the panels.

Fig. 5 shows the weakness of joints at acute angles, resulting in corner breaks.

An interesting joint of a proprietary nature is that designed by Mr. J. H. Walker, M.Inst.C.E. This is extremely simple, does not add anything appreciable to the cost of construction above the cost of a butt joint and meets the need of those who require strength at the joint without using steel rods through it. It is obviously intended for use in panels of short length. The photograph and diagram (*Figs.* 6 and 7), show the general principle, which is that of interlocking teeth of concrete, the teeth being half the depth of the concrete slab and alternately in the top and bottom portion. Wherever the author has seen this joint employed it has proved most satisfactory.

(*To be Continued.*)

Formwork.

To those of our readers who have not yet secured their copy of Mr. Wynn's new book on formwork* we would recommend the perusal of a review of the volume that appeared in "Engineering" for June 10. In view of the value of this volume from the points of view of economising in labour, preventing wastage of materials, and adopting the simplest method of shuttering for any particular work in hand, we have no hesitation in printing the following abstract of the review in question:

"This book will be welcomed by all engaged on the construction of works in reinforced concrete or on designs of reinforced concrete structures which, if they are to be economically carried out, involve a considerable working knowledge of the character of the formwork used in their erection.

"It is evident that the author's experience of formwork in all its intricacies is very complete, and he has spared no pains to place this knowledge at the disposal of his readers in a thorough and comprehensive manner. In dealing with such a subject as this, if the essential requirements are to be clearly presented, a treatise must be illustrated by means of both photographs and drawings. This has been realised by the author, whose efforts in this direction leave nothing to be desired.

"Any who may for the first time be contemplating taking in hand reinforced concrete construction, as well as those who have already some experience of this work, will find in Mr. Wynn's book much that will aid them in handling the problem of forms and shuttering efficiently and economically. The book is full of useful data and practical suggestion for the design, pricing, erection and removal of various types of formwork, and however experienced a reader may consider himself he will hardly fail to obtain further enlightenment on this subject.

"Throughout the book the author has dealt with the costing of the various types of formwork on the man-hour basis, giving very full details with respect to the materials used. This method enables costs to be assessed with a considerable degree of accuracy for any rates of labour and costs of materials which may obtain at the site of the work.

"For those who through extended experience have gained considerable knowledge of these matters, the hints given on the economical cutting and use of timber and the methods which may be adopted to get the best use from the materials employed, together with the detailed data with respect to quantities and labour, cannot fail to be of inestimable service.

"A section of the book is devoted to the design of the formwork required for the several members of a structure; the essential theoretical treatment is dealt with in a brief and simple manner, much useful information being given regarding various materials and appliances and their most economical use. A useful and comprehensive series of tables is included, setting out the sizes and positions of the several parts, as derived from the formulæ previously given.

"Following the tables is a complete set of examples, showing how they can be applied in the design of various kinds of formwork, each example being accompanied by a useful detailed sketch of the form and its various parts. The extensive nature of these examples will be realised when it is mentioned that they include the moulds and supports for slabs, beams, girders, columns and walls of various dimensions, light ribbed floors of several types, flat slab or mushroom floors, haunches to beams and stairways.

"The author then deals in considerable detail with the construction of the formwork for different members of a structure, giving full details of the sizes of members and methods to be employed in erection and stripping.

"After dealing with each particular type of formwork, the author gives complete details requisite for estimating the cost of the making, erection and stripping, and there is little doubt that if Mr. Wynn's advice and recommendations are followed, the prices derived from the factors given can be used with confidence when assessing the cost of the formwork."

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* "Design and Construction of Formwork for Concrete Structures," 320 pp.; 219 illustrations; 12 *folders*; 11 design tables. By A. E. Wynn, B.Sc., A.M.Am.Inst.C.E. London: Concrete Publications Limited, 20 Dartmouth Street, Westminster, S.W.1. Price 20s. net. (Postage, 9*d.* extra.)

DATA FOR PRICING REINFORCED CONCRETE.*

MATERIALS DELIVERED 4 MILES FROM CHARING CROSS.

		s.	d.
Best Washed Sand	per yard	13	6
Clean Shingle, ¾ in. mesh	„	12	6
„ „ ½ in. mesh	„	13	6
Thames ballast	„	10	6
Broken brick (¾ in.)	„	11	6
Best British Portland Cement (delivered London area)	per ton 53s. to	55	0
Rapid-Hardening Portland Cement	delivered London 10s. per ton extra		
"Super-Cement"	per ton 88s. to	93	0
"Lightning" Brand Aluminous Cement	„ 100s. to	105	6
Ciment Fondu	works f.o.r.	95	0

Boarding for Shuttering—

		Sawn. s.	Sawn. d.	Wrot. s.	Wrot. d.
1 in.	per square	23	6	27	6
1¼ in.	„	29	6	33	6
1½ in.	„	35	6	41	0

Sawn Timber for Struts and Supports—

3 in. by 4 in.	from £22 per standard
3 in. by 6 in. and 3 in. by 7 in.	„ £20 „ „

Mild Steel Rods for Reinforcement—

		s.	d.
⅝ in. to 2⅞ in. Rounds	per cwt.	10	6
9/16 in. to ½ in. Rounds	„	10	9
⅜ in. Rounds	„	11	0
¼ in. Rounds	„	12	0

Breeze Slabs per yd. super: 2 in., 1/11; 2½ in., 2/4; 3 in., 2/9; 4 in., 3/6.

MATERIAL AND LABOUR, INCLUDING 10 PER CENT. PROFIT.

(Based on Contracts up to £2,000.)

Portland Cement Concrete well mixed in proportion 1 : 2 : 4—

				s.	d.
Do.	do.	in foundation	per foot cube	1	9
Do.	do.	in columns	„ „	1	11
Do.	do.	in beams	„ „	2	1
Do.	do.	in floor slabs 4 in. thick	per yard super	5	8
Do.	do.	in floor slabs 5 in. thick	„ „	7	0
Do.	do.	in floor slabs 6 in. thick	„ „	8	6
Do.	do.	in floor slabs 7 in. thick	„ „	9	10
Do.	do.	in walls 6 in. thick	„ „	8	2

(Add for hoisting 3s. 6d. per yard cube above ground-floor level. Add for "Ferrocrete" 1s. 10d. per yard cube.)

Steel Reinforcement, including Cutting, Bending and putting into Position and securing with Stout Binding Wire—

		s.	d.
From ¼ in. to ⅜ in.	per cwt.	22	6
„ 9/16 in. to ½ in.	„	21	6
„ ⅝ in. to 2⅞ in.	„	20	6

EXTRA LABOUR TO BENDS in ¼-in. rods, ½d.; ⅜-in. rods, 1d.; ½-in. rods, 1¼d.; ⅝-in. rods, 1½d.; ¾-in. rods, 1¾d.; ⅞-in. rods, 2d.; 1-in. rods, 2¼d.; 1⅛-in. rods, 3d.; 1¼-in. rods, 3½d.; 1⅜-in. rods, 4½d.; 1½-in. rods, 6d. (per bend per cwt.).

EXTRA LABOUR TO HOOK BENDS: ¼ in., 1d.; ⅜ in., 2d.; ½ in., 2½d.; ⅝ in., 3d.; ¾ in., 3½d.; ⅞ in., 4d.; 1 in., 4½d.; 1⅛ in., 6d.; 1¼ in., 7d. (per bend per cwt.).

Shuttering—

		s.	d.
Shuttering and Supports for Concrete Walls (both sides measured)	per square	59	0
Centering to Soffits of Reinforced Concrete Floors and Strutting, average 10 ft. high	per square	55	0
Do. do. in small quantities	per ft. super	0	10
Shuttering and Supports to Stanchions for easy removal, average 18 in. by 18 in.	per ft. super	0	11½
Do. do. as last, in narrow widths	„ „	1	1½
Do. do. to sides and soffits of beams, average 9 in. by 12 in.	„ „	1	1½
Do. do. as last, in narrow widths	„ „	1	3½
Raking, cutting, and waste to shuttering	per ft. run	0	3
Labour, splay on ditto	„ „	0	2
Small angle fillets fixed to internal angles of shuttering to form chamfer	„ „	0	3

WAGES.—The rates of wages on which the above prices are based are:—Carpenters and joiners, 1/9½ per hour; Carpenters working on old shuttering, 1/10½; Labourers on building works, 1/4½; Men on mixers and hoists, 1/5½; Bar-benders, 1/5½.

[* This Data is specially compiled for *Concrete and Constructional Engineering*, and is strictly copyright.]

Prospective New Concrete Work.

Abergele.—*Road.*—The St. Asaph R.D.C. has recommended the Denbighshire C.C. to construct a 20-ft. carriage-way from Foryd Bridge to the Abergele boundary. The cost is estimated at £17,000.

Ayr.—*Houses.*—The T.C. proposes to build 300 houses.

Bath.—*Reservoir.*—The Corporation is considering a scheme for the provision of a reservoir.

Becontree.—*Houses.*—The L.C.C. proposes to erect 2,500 houses on the estate at Becontree. The cost is estimated at £1,450,000.

Brighton.—*Cliff Road.*—The T.C. is preparing a scheme for the construction of an undercliff drive from Brighton to Rottingdean. The cost is estimated at £1,000,000.

Brynmarlias.—*Bridge.*—The Llandovery R.D.C. is considering the construction of a bridge at Brynmarlias.

Chertsey. — *Houses.*—The Housing Committee has recommended the U.D.C. to erect 50 houses on a site near Courtland, Addlestone.

Clevedon.—*Wall.*—The provision of a boating and bathing lake at Salthouse Bay will include the construction of a 1,000-ft. wall.

Cramlington. — *Houses.*—The Housing Committee has submitted a scheme to the U.D.C. for the construction of 100 three-room houses.

Darlaston.—*Houses.*—A scheme is being prepared for the construction of 380 houses.

Easington. — *Houses.* — Application has been made for permission to borrow £50,000 for housing purposes.

Erith. — *Houses.* — The U.D.C. has asked the surveyor to prepare a scheme for the construction of 100 houses.

Gloucester. — *Bridge.* — The Gloucester Corporation has approached the Newent R.D.C. for payment towards the construction of a new Ketford Bridge.

Gorleston.—*Sea Wall, etc.*—The Gt. Yarmouth T.C. is considering a scheme for extending the parade and sea wall at Gorleston.

Gorwyllt.—*Bridge.*—The Llanfyllin R.D.C. proposes to construct a bridge at Gorwyllt.

Grays (Essex).—*Houses.*—The U.D.C. proposes to erect 50 houses, at a cost of £24,500.

Harrogate.—*Road.*—Plans for the construction of a relief road have been submitted to the County Highways Committee.

Huddersfield. — *Houses.* — The T.C. has applied for sanction to borrow £21,000 for the construction of 70 houses in St. Andrew's Road.

Jarrow.—*Houses.*—The T.C. is seeking permission to erect 50 houses.

London.—*Houses.*—The L.C.C. proposes to build 1,132 houses on the Downham estate, at a cost of £710,000.

Newcastle-on-Tyne. — *Houses.* — The T.C. has purchased a site on which to erect 850 houses.

Newry (Ireland). — *Bridge.* — The U.D.C. has applied for permission to borrow £6,000 for the construction of a bridge over the canal at Monaghan Street to replace Godfrey Bridge.

Padstow. — *Pier.* — The Southern Railway Co. proposes to spend £13,000 on extending the East Pier at Padstow.

Pudsey.—*Houses.*—The T.C. proposes to build 200 houses.

Redruth. — *Houses.* — The U.D.C. is negotiating for a site on which to build 50 houses.

Rhos-on-Sea.—*Roads.*—The Colwyn Bay U.D.C. proposes to construct roads from Dinerth and Llandudno Roads.

Rochdale. — *Embankment.* — The Corporation has applied for permission to borrow £72,850 for strengthening the Warland reservoir embankment.

Ross.—*Houses.*—The U.D.C. has given instructions for plans to be prepared for the contruction of 50 houses.

Scotswood. — *Bridge.* — The Durham C.C. is considering a scheme for the construction of a bridge to replace Scotswood Bridge. The cost is estimated at £500,000.

Skegby. — *Houses.* — Application has been made for sanction to erect 30 houses.

Sowerby Bridge. — *Houses.* — The U.D.C. proposes to build 52 houses on the Beachwood estate.

Stockport. — *Concrete Boxes.* — A scheme is being considered for the construction of 18 police boxes in reinforced concrete, at a cost of £50 each.

Stourport. — *Concrete Bridge.* — The

District Council proposes to erect a reinforced concrete bridge over the canal to replace the existing structure.

Stretford. — *Houses.* — The U.D.C. is negotiating for the purchase of a 28-acre site for housing purposes.

Swansea.—*Houses.*—The Corporation Housing Committee has applied for sanction to erect 100 houses.

Thame.—*Houses.*—The U.D.C. has decided to build 22 houses.

Torquay.—*Sea Defence Works.*—The T.C. has applied for sanction to borrow money for strengthening the boundary wall on the Beacon Cove.

Tunbridge Wells.—*Houses.*—The T.C. proposes to build 50 houses

Ulverston.—*Houses.* — The U.D.C. proposes to spend £35,000 on the construction of 70 houses.

Upton, I.O.W.—*Reservoir.*—The Isle of Wight R.D.C. is negotiating for a site on which to construct a reservoir.

Ventnor.—*Concrete Groynes.*—The U.D.C. has applied for sanction to borrow £1,000 for the construction of two concrete groynes.

Wadhurst.—*Reservoir.*—The Crowborough Water Co. has informed the Ticehurst R.D.C. of its intention to construct a reservoir at Best Beech Hill.

Wakefield. — *Houses.* — The City Council is seeking permission to borrow £98,808 for the construction of 200 houses at Snapethorpe.

Walton, Surrey. — *Road.* — The U.D.C. proposes to construct a road from High Street to Walton Bridge.

West Bromwich. — *Houses.* — The T.C. proposes to spend £500,000 on the construction of 1,200 houses.

Wolverhampton. — *Houses.* — The T.C. proposes to erect 200 houses on the Low Hill estate.

Woolwich (London). — *Houses.* — The B.C. has applied for sanction to borrow £34,530 for the construction of 65 houses on its estate at Eltham.

Workington.—*Houses.*—The T.C. is seeking permission to borrow £50,579 for the erection of 100 houses.

Worksop.—*Houses.*—The U.D.C. is seeking permission to borrow £40,000 for housing purposes.

Wrexham.—*Houses.*—The R.D.C. proposes to spend £53,000 on the construction of 50 houses in the rural area.

Tenders Accepted.

Baglan.—*Concrete Sewer.*—The Port Talbot T.C. has accepted the tender of Mr. B. Chaplin, Cardiff, at £28,649, for the construction of concrete pipe sewers at Baglan.

Other tenders submitted : C. Parker, £29,811 ; T. Walker, £31,924 ; D. Middleton, £33,979 ; South Wales Contractors, £50,523.

Bromley.—*Concrete Sewer.*—The West Kent Main Sewerage Board has accepted the tender of Messrs. W. & C. French, at £13,588, for the construction of 3,000 yards of concrete tube sewer.

Burntisland. — *Concrete Pavement.* — The T.C. has accepted the tender of Messrs. W. Grant & Sons, Kirkcaldy, at £352, for the construction of 700 sq. yds. of concrete pavement.

Cork.—*Concrete Road.*—The Corporation has accepted the tender of Mr. P. Molloy, Church Street, Limerick, at £16,009 14*s.*, for reconstructing O'Connel Avenue in reinforced concrete.

Other tenders submitted : J. Kenny & Sons, £16,090 14*s.* ; T. Gough, £16,316 7*s.* 9*d.* ; P. Dillon, £16,530 4*s.* 3*d.* ; J. Harrison & Co., £16,564 5*s.* 6*d.* ; G. Winkey & Co., £16,931 16*s.* 8*d.* ; T. J. Moran & Co., £20,874 12*s.* 6*d.* ; Northern Concrete Road Construction Co., £25,960 15*s.*

Dundee.—*Concrete Floors.*—The T.C. has accepted the tender of Messrs. C. Dick & Son, Monifieth, at £6,244, for the construction of reinforced concrete floors and roads in connection with the new slaughterhouses.

Hull.—*Concrete Sewer.*—The T.C. has accepted the tender of Mr. G. Curtis, Melrose Street, Hull, for the construction of a concrete sewer in Pickering Road.

Kingston (Isle of Wight).—*Concrete Raft.*—The Isle of Wight Electric Light & Power Company has accepted the tender of Messrs. F. Bevis, Ltd., at £1,805, for the construction of a reinforced concrete raft.

Other tenders submitted: Wort & Way, £2,459 13*s*. 4*d*.; J. F. Blair & Co., £2,267; Jenkins & Sons, £2,025; J. Ball & Sons, £1,974; H. Moger, £1,897 10*s*. 9*d*.

LLANDDEUSANT.—*Concrete Bridge*.—The Llandovery R.D.C. has accepted the tender of the Bituminous Macadam Co., Llanelly, at £370, for the construction of a reinforced concrete bridge over the River Swadde.

LONDON.—The Bethnal Green B.C. has accepted the tender of Messrs. Industrial Constructions, Ltd., at £1,805, for reinforced concrete work at the Electricity sub-station in St. Andrew's Street.

MARCH.—*Concrete Roads*.—The Isle of Ely C.C. has accepted the tenders of Mr. W. H. Rogers, Willenhall, at £6,111, for constructing Ely-Prickwillow and Stretham Roads in reinforced concrete.

MANCHESTER.—*Concrete Houses*.—The Corporation has accepted the tender of the Corolite Construction Co., Ltd., at £113,480, for the construction of 250 concrete houses on the Ladyburn estate.

MANCHESTER.—*Building*.—The Regent Bridge Warehousing Co. has accepted the tender of Messrs. Matthews & Mumby, Ltd., for the construction of a two-story reinforced concrete building.

OSWESTRY.—*Concrete Reservoir*.—The T.C. has accepted the tender of Messrs. Whitley Bros., Salisbury Road, Wrexham, at £4,845, for the construction of a concrete service reservoir with a reinforced concrete roof, filter house, mains, drain, and other works.

Other tenders submitted: R. E. Jeavons & Co., £4,889; Wyatt Bros., £4,989; J. Dickinson & Co., Ltd., £5,159; C. Kearton & Partners, £5,188; Hobrough & Co., Ltd., £5,346; J. W. Thornley & Sons, £5,500; J. Byrom, Ltd., £5,619; D. Thomson & Sons, £5,799; West's Rotinoff Piling & Construction Co., £6,150; W. Muirhead, Macdonald Wilson & Co., £6,811.

SLIGO.—*Concrete Shed*.—The Harbour Commissioners have accepted the tender of Messrs. W. Costello & Sons for the construction of a concrete shed.

WHITCHURCH (HANTS). — *Concrete Water Tower*.—The R.D.C. has accepted the tender of Johnson's Reinforced Concrete Engineering Co., Ltd., at £2,855, for the construction of a 180,000-gallon reinforced concrete water tank and motor house.

Other tenders submitted: Civil Engineering Constructions, £2,557; Mussellwhite & Son, £3,108; Industrial Constructions, Ltd., £3,140; J. Howard & Co., £3,232; E. E. Jeavons & Co., Ltd., £3,411; F. Mitchell & Son, Ltd., £3,781; W. Jones & Sons, Ltd., £3,974; Holloway Bros., Ltd., £3,974; G. Pollard & Co., Ltd., £4,247; Durnford Construction Co., Ltd., £5,101; H. Middleton, £5,259; Gray's Ferro-Concrete Co., Ltd., £3,782.

WHITCHURCH (HANTS). — *Concrete Bridges*.—The R.D.C. has accepted the tender of Mr. G. K. Waghorn, Chestnut Road, West Norwood, at £392, for the construction of two concrete bridges across the water splashes in Church Street, Overton.

Other tenders submitted: J. Howard & Co., £663; J. Mitchell & Sons, Ltd., £665; E. E. Jeavons & Co., Ltd., £698; J. T. Mackley & Co., Ltd., £710; Johnson's Reinforced Concrete Engineering Co., Ltd., £717; H. Middleton, £882.

DUCKHAM'S
CONCRETE
MOULD
OIL

GOES FARTHEST
FUNCTIONS BEST

ALEXANDER DUCKHAM & Co., Ltd.
6 BROAD ST. PLACE, LONDON, E.C.2

PARTNERSHIP.

REINFORCED Concrete Specialist (M.B.E., A.M.I.C.E.), 20 years' experience—home and abroad—design, formwork, plant, organisation and competitive pricing, desires partnership with reliable firm of Contractors. Capital available. Box 1275, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 20 Dartmouth Street, Westminster, S.W.1.

The New Nile Dam.

THE new barrage on the Nile at Nag Hammadi forms the next step in the irrigation of the Nile, which commenced in 1899 with the construction of the famous Assouan Dam, followed by the Esna Barrage in 1908 and the Sennar Dam opened in January of last year. The site for the proposed barrage which will be over half a mile in length is situated some 500 miles up the river between the existing barrages of Assiut and Esna.

The object of the barrage is to raise the level of the river up-stream sufficiently to command the irrigation canal which will take off just above the barrage, and thereby irrigate an area of approximately 500,000 acres at all seasons of the year, formerly only possible at a time of high flood. The contract for the barrage has been placed with Messrs. Sir John Jackson, Ltd., while Messrs. Ransomes & Rapier, Ltd., are to supply the sluice gates and operating machines. This contract consists of roller type gates for the 100 openings on the main barrage and for the 6 openings at the head of the irrigation canal. Each opening is provided with two gates of 6-metres span running in parallel grooves which will permit of their being lifted out separately if desired. These gates have a depth of 6·1, 7·1, and 8·1 metres respectively, according to their position in the barrage. Two power-driven machines travelling on rails on top of the barrage will be provided for operating the gates to regulate the flow of water through the openings, and also for removing the gates when necessary. A small machine will work on the canal head for the regulation of the gates controlling the flow of water into the canal.

Recent Patent Applications.

250,246.—Soc. Anon. Des Chaux et Ciments de Lafarge et Du Teil: Manufacture of cement.

263,865.—J. Girlot: Building blocks.

268,736.—E. C. Eckel: Cement, and process of making same.

273,374.—C. Bailey: Machines for moulding concrete blocks.

273,445.—R. Hickton and W. Bagguley: Machines for making concrete blocks.

273,477.—British Dyestuffs Corporation. Ltd., J. Baddiley, A. Shepherdson and A. Davidson: Colouring of cement and concrete.

273,787.—K. D. Mackenzie: Building slabs.

274,291.—C. W. Glover and H. F. Smith: Construction of floors or ceilings.

New Company Registered.

BREESLABS, Ltd. (223261) Registered July 18. 31, Great Queen-street, Kingsway, W.C.2. Manufacturers of breeze slabs and concrete blocks. Nominal capital: £1,510. Directors: C. B. Peake, Rigton, Burnt Ash-lane, Bromley, Kent; J. H. H. Taylor, Station Hotel, Harborough, Lincoln.

Trade Notices.

B.R.C. Leeds Representative.—Major H. A. Butterfield, A.M.Inst.C.E., P.A.S.I., has been appointed Roads Representative for The British Reinforced Concrete Engineering Co., Ltd., for the Leeds Area. The address of the Leeds office is 5, East Parade.

A New Mixer.—Messrs. Winget (1924), Ltd., of Winget House, Grosvenor Gardens, London, S.W.1, have issued a brochure giving full particulars and illustrations of their new open-drum with the special Burn-Lancaster drum.

"Ransome" Mixers and Plant.

MESSRS. RANSOMES & RAPIER, LTD., Ipswich, who have been the sole manufacturers of "Ransome" concrete mixers since 1907, have recently acquired the selling rights, patents, and goodwill of Ransome Machinery Co. (1920), Ltd., and will accordingly market the mixers themselves in future.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XXII. No. 10. LONDON, OCTOBER, 1927.

EDITORIAL NOTES.

Fire Resistance of Concrete.

As a result of experience in actual conflagrations, concrete has gained a high reputation as a fire-resisting constructional material, although as is shown by the report on " Fire Resistant Construction " (published by the Building Research Board and reviewed on another page of this issue) both cement and certain aggregates possess elements of weakness which tend to make concrete susceptible to damage by fire. Set cement contains hydrate of lime which, when submitted to a temperature of 850 deg. F., is changed into quicklime with a measure of contraction, while the subsequent wetting or weathering slakes the quicklime with a measure of expansion, leading to partial or complete destruction of the concrete. Aggregates containing quartz are the subject of physical changes upon heating which cause their disintegration, while other aggregates, such as limestone, undergo chemical changes at high temperatures, also leading to destruction of concrete. It has been the aim of the Building Research Board to show that there are means for improving the fire-resisting qualities of concrete, and it may be that the results of the investigations now published will lead to an important development in the building industry.

It is claimed that by the addition of pozzolana to cement the proportion of free hydrate of lime in the set cement is much reduced and the resistance to fire correspondingly increased. The figures in the pamphlet certainly show that remarkable strength remains in specimens of concrete containing pozzolana after submission to severe laboratory tests at high temperatures. The commercial development of this investigation almost certainly lies with the cement manufacturers, because the location of a suitable pozzolana, its grinding to the fine powder that is necessary, and its intimate mixing with cement, are outside the province of the concreter. The pozzolana which would probably be most favoured is clay burnt at a definite temperature, and this in itself constitutes a separate manufacture.

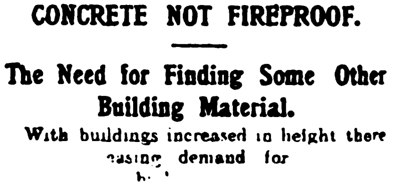
It is unfortunate that the addition of pozzolana to concrete reduces the strength of the latter, because all the efforts of cement manufacturers and of scientific concreters have been towards the production of stronger cement and stronger concrete. It may be that the rapid-hardening cements of high strength will alone be the means of making the Building Research Board's proposals practicable. It will be for the cement manufacturers to decide whether it is possible to market on a commercial scale a cement-pozzolana mixture which will possess the quality of improved fire resistance without losing any of the strength which is the pride of the up-to-date cement salesman.

The addition of pozzolana to concrete, although a new proposal in connection with fire resistance, is well-established on the Continent as a means of protection against the action of sea water, but for this purpose is almost unknown in Great Britain. There are probably two reasons for this: first, that natural pozzolana does not exist in this country; and second, the absence of convincing evidence that well-made concrete needs protection against the chemical action of sea water. It is equally possible that the engineer and building owner may decide that the recommendations of the Research Board are also akin to painting the lily, and that the measure of fire resistance shown by modern concrete construction in recent experience is all that can reasonably be required.

One of the objections to the addition of any extraneous material to cement has been the opportunities that present themselves of abuse by adulteration, and although this objection would not apply to the products of reputable British manufacturers it is satisfactory to learn that there are now methods of estimating the pozzolanic qualities of materials and of determining the proportion of free lime in set cement which pozzolana may be expected to reduce.

• • • • •

This technical report on a scientific investigation undertaken with the object of ascertaining if it is possible still further to improve the fire-resisting properties of the most fire-resistant of all building materials has been seized upon by the non-technical press. Garbled and uninformed paragraphs have been the order of the day. How the *Irish News* interprets the findings of the Building Research Board is shown in the headlines reproduced, which covered a quarter of a column suggesting by inference that it should be a criminal offence to use concrete in buildings. We welcome the increasing interest the daily press takes in building matters, but we do suggest that a newspaper should treat a scientific report as a serious subject, and not skim through it in search of sensation. We have become accustomed to a section of the daily press giving the impression that the last meeting of the British Association did nothing but talk about the evolution of man, and to see reports of educational conferences confined to sensational extracts from the least important paper if it happens to deal with birth control; if building is to be discussed in the same way, we hope concrete will be overlooked as too tough a subject even for the "*Irish* News."



CONCRETE NOT FIREPROOF.

The Need for Finding Some Other Building Material.

With buildings increased in height there
asing demand for

Deterioration of Structures in Sea Water.

THE Seventh (Interim) Report of the Committee of the Institution of Civil Engineers on The Deterioration of Structures in Sea Water has just been issued (H.M. Stationery Office, price 2s.). This contains reports from several quarters of the action of sea water on timber and steel. No further reports are included on reinforced concrete, but it is stated that the Committee has received from Mr. Marchbanks information of the exposure, over a period of seven years, of two reinforced concrete piles of 1 : 1½ : 3 mixture, 10 ft. long, in which the reinforcement is so placed as to give depths of cover of 1 in., 1½ in., 2 in., and 2½ in. The specimens were placed so that the lowest 2 ft. were continuously in the water, the next 4 ft. were subject to the rise and fall of tide, and the upper 4 ft. were above water-level. A thorough examination has shown the pieces to be perfectly sound, and by stripping a length of cover off the reinforcement it has been ascertained that the latter is everywhere free from rust. The specimens have been repaired where stripped and re-exposed. One of them had been originally tarred, but this coating is disappearing. Though the experiment so far has given negative results, the Committee hope that it will lead to information as to the protective value of increased depth of cover.

The Committee has under consideration the question of instituting experiments to ascertain the permeability of concrete to sea water and air, and has been in communication with Dr. R. E. Stradling, of the Building Research Board, with a view to the preparation of a suitable programme.

Sulphur Impregnation as Concrete Strengthener.

EXPERIMENTS conducted over a number of years by the Testing Department of the North Carolina State Highway Commission prove, it is claimed, that the impregnation of concrete with sulphur results in an appreciable increase in strength and a decrease in absorptive properties, and that this is brought about by the impregnation process irrespective of the age of the concrete. Thus tests have been made with specimens impregnated at ages of from seven days to three months after manufacture, and in all cases the increase of strength and decrease of absorption are approximately the same. The tabulated results of these tests show that the sulphur treatment increases the tensile strength of test pieces by over 500 per cent. and the compressive strength by about 450 per cent. Sulphur-impregnated specimens are stated to absorb water to the extent of less than 2 per cent. Elsewhere in this number we give some further particulars of the process, and the tests upon which the above statements are based.

Stone-Crushing and Screening Plant for Argentina.

THE Commercial Secretary at Buenos Aires reports that the Department of Navigation and Ports of the Argentine Ministry of Public Works is inviting tenders, to be presented by November 14, 1927, for the supply and erection at Comodoro Rivadavia of a complete rubble grinding installation capable of an out put of ten metric tons of sand per hour. Local representation is essential. United Kingdom firms in a position to supply British materials can obtain further particulars regarding this call for tenders on application to the Department of Overseas Trade, 35, Old Queen Street, London, S.W.1. (Reference A. X. 5278).

Slabs Reinforced in Two Directions.

An extension to Grashof and Rankine's Theory.

By GORDON WELCH, B.Sc., A.M.Inst.C.E., A.C.G.I.

THE curves generally known as "Grashof & Rankine's" for determining the bending moments in a slab reinforced in two directions are held to apply with reasonable accuracy to cases where the slab is either freely supported or fixed at its four edges. From an examination of the principle upon which these curves are based, however, it is apparent that they cannot be applied to cases where the end conditions of fixation at two opposite edges differ from those obtaining at the other two edges.

The principle upon which Grashof & Rankine's curves are based is simply that the proportion of the total load carried by the slab reinforcement in one direction is to the proportion of the load carried in the other direction in the ratio of the deflections caused by these loads, the deflections in the two directions being equal: or, in symbols,

If W = the load per sq. ft. on the slab; W_1 = the proportion carried in direction of span l_1; and W_2 = the proportion carried in direction of span l_2.

Then for a slab freely supported at all four edges the deflection in span l_1 will be:—

$$\Delta_1 = \frac{5 \cdot W_1 l_1^4}{384\, E.I.}$$

and the deflection in span l_2 will be

$$\Delta_2 = \frac{5\, W_2 l_2^4}{384\, E.I.}.$$

Now $\Delta_1 = \Delta_2$ and assuming $E.I.$ is constant, we have:—

$$W_1 l_1^4 = W_2 l_2^4.$$

Also $$W_1 + W_2 = W.$$

Solving these two equations for W_1 and W_2 we have

$$W_1 = \frac{W.l_2^4}{l_1^4 + l_2^4} \quad \text{and} \quad W_2 = \frac{W.l_1^4}{l_1^4 + l_2^4}.$$

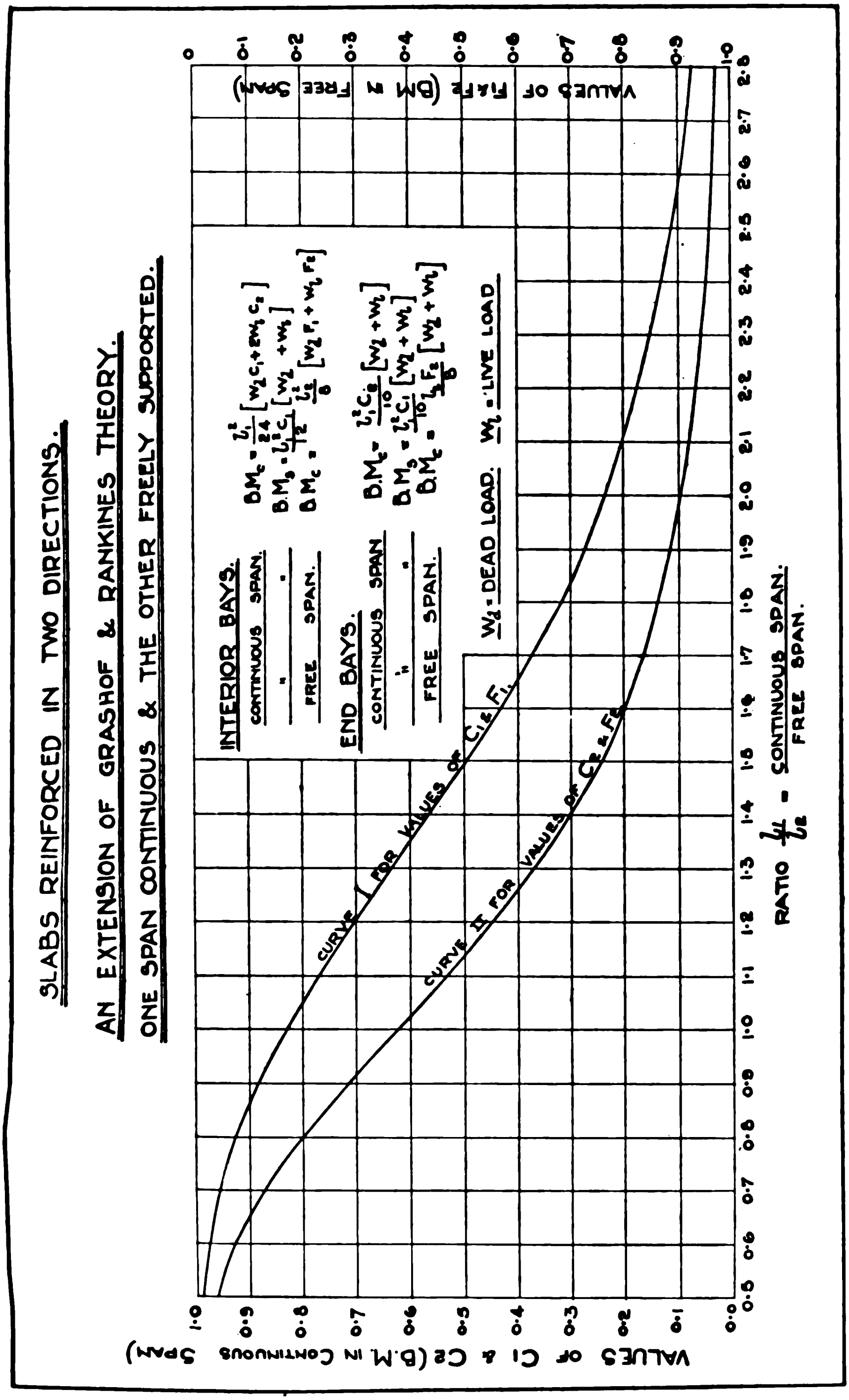
The bending moment in span l_1 will then be:—

$$\frac{W_1 l_1^2}{8} = \frac{W.l_1^2}{8}\left[\frac{l_2^4}{l_1^4 + l_2^4}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Similarly the bending moment in span l_2 will be:—

$$\frac{W_2 l_2^2}{8} = \frac{W.l_2^2}{8}\left[\frac{l_1^4}{l_1^4 + l_2^4}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

By plotting the values of the expressions in brackets for various ratios of l_1 to l_2, the curves of Grashof & Rankine are obtained. From equations (1) and (2) it will be seen that the bending moment in either direction is simply the ordinary bending moment (for whatever end conditions are assumed) multiplied by a factor depending on the ratio of the spans; and this is true provided the end conditions are exactly similar at adjacent edges.


SLABS REINFORCED IN TWO DIRECTIONS.
AN EXTENSION OF GRASHOF & RANKINES THEORY.
ONE SPAN CONTINUOUS & THE OTHER FREELY SUPPORTED.
INTERIOR BAYS.
CONTINUOUS SPAN. $B.M_c = \frac{l_1^2}{24}[W_d C_1 + 2W_l C_2]$
" " $B.M_s = \frac{l_1^2 C_1}{12}[W_d + W_l]$
FREE SPAN. $B.M_c = \frac{l_2^2}{8}[W_d F_1 + W_l F_2]$
END BAYS.
CONTINUOUS SPAN $B.M_c = \frac{l_1^2 C_1}{10}[W_d + W_l]$
" $B.M_s = \frac{l_1^2 C_1}{10}[W_d + W_l]$
FREE SPAN. $B.M_c = \frac{l_2^2 F_2}{8}[W_d + W_l]$
W_d = DEAD LOAD. W_l = LIVE LOAD
CURVE I FOR VALUES OF C_1 & F_1.
CURVE II FOR VALUES OF C_2 & F_2
VALUES OF F_1 & F_2 (BM IN FREE SPAN)
0
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
VALUES OF C1 & C2 (B.M. IN CONTINUOUS SPAN)
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0·0
0·5
0·6
0·7
0·8
0·9
1·0
1·1
1·2
1·3
1·4
1·5
1·6
1·7
1·8
1·9
2·0
2·1
2·2
2·3
2·4
2·5
2·6
2·7
2·8
RATIO $\frac{l_1}{l_2}$ = $\frac{\text{CONTINUOUS SPAN.}}{\text{FREE SPAN.}}$

When, however, this proviso does not hold, as when one span has fixed ends and the other is freely supported, other curves must be obtained taking into account the difference in the two cases. As before

let $W_1 =$ the proportion of the load carried by span l_1
and $W_2 =$ the proportion of the load carried by span l_2.

Let $W =$ the load per square foot on the slab, and suppose span l_1 to be perfectly fixed at the ends and span l_2 to be simply supported. The deflections Δ_1 and Δ_2 will then be :—

$$\Delta_1 = \frac{W_1 l_1^4}{384\,E.I.} \quad \text{and} \quad \Delta_2 = \frac{5\,W_2 l_2^4}{384\,E.I}.$$

Again $\Delta_1 = \Delta_2$ and assuming $E.I.$ to be constant

$$W_1 l_1^4 = 5 W_2 l_2^4.$$

Also
$$W_1 + W_2 = W.$$

Solving these two equations for W_1 and W_2 we have :—

$$W_1 = \frac{5 l_2^4.W}{l_1^4 + 5 l_2^4} \quad \text{and} \quad W_2 = \frac{l_1^4.W}{l_1^4 + 5 l_2^4}.$$

Since W_1 refers to the fixed span, the bending moment in span l_1 near the centre of the span will be

$$\text{B.M} = \frac{W_1 l_1^2}{24} = \frac{W.l_1^2}{24}\left[\frac{5 l_2^4}{l_1^4 + 5 l_2^4}\right] = \frac{W.l_1^2}{24} C_1.$$

Similarly the bending moment in span l_2 will be :—

$$\text{B.M} = \frac{W_2 l_2^2}{8} = \frac{W.l_2^2}{8}\left[\frac{l_1^4}{l_1^4 + 5 l_2^4}\right] = \frac{W.l_2^2}{8}.F_1.$$

Where C_1 and F_1 are factors depending upon the ratio of the spans.

Curve I has been derived in this way for the case of slabs one direction fixed and the other freely supported, and *Curve* II for the case one direction partially fixed (as in a continuous slab under live load with alternate bays loaded) and the other freely supported. It is considered that these curves, together with the standard curves for both spans under similar end conditions as given in the appendix to the R.I.B.A. Regulations, will be sufficient to cover most practical cases within the limits of accuracy of the assumptions made.

It should be noted that in designing the continuous spans for live load of a slab which is freely supported transversely the bending moment at midspan, which is a maximum when alternate bays are loaded, may be found by means of *Curve* II (for ends partially fixed), but the moments at supports which will be a maximum when adjacent bays are loaded are to be obtained by the aid of *Curve* I, and in this case the ends of the slab may be assumed practically fixed. This is not quite true, but may be taken as a fair approximation.

For end spans the subject is more complex owing to the fact that the position and the value of maximum deflection in the continuous span varies for dead and live loads and when different numbers of spans are considered. For these reasons a mathematically exact treatment of the subject fails from a practical point of view.

However, for the end span of three spans it is found that *Curve* II may be applied for both dead and live load moments at midspan without serious error, it being borne in mind that results thus obtained will be somewhat on the high side for live load and on the low side for dead load in the continuous span and vice versa in the transverse span. Curves drawn for dead and live load moments show that *Curve* II lies almost exactly midway between them, and that the maximum variation of these curves occurs for a ratio of $\frac{l_1}{l_2} = 1{\cdot}1$, when the actual values of C_2 for dead and live loads is 0·59 and 0·47 respectively which is a variation of only 0·06 above and below the value found by use of *Curve* II. Towards either extreme of $\frac{l_1}{l_2}$ such curves converge gradually to *Curve* II.

As an example of the use of the curves we will take the case of a number of continuous bays each 12 ft. span and the transverse span of 10 ft. being freely supported.

Then ratio of spans $\frac{\text{Continuous span}}{\text{Free span}} = 1{\cdot}2$

From Curve I: $C_1 = 0{\cdot}7$ and $F_1 = 0{\cdot}3$
„ „ II: $C_2 = 0{\cdot}45$ „ $F_2 = 0{\cdot}55$

Suppose the dead load = 100 lbs./sq. ft. and live load = 200 lbs./sq. ft.

Centre Spans.

$$B.M_C \text{ (continuous span)} = \frac{12^2}{24}[100 \times 0{\cdot}7 + 2 \times 200 \times 0{\cdot}45]$$
$$= \underline{1500} \text{ lbs. feet.}$$

$$B.M_S \text{ („ „)} = \frac{12^2}{12}[100 + 200] \times 0{\cdot}7$$
$$= \underline{2520} \text{ lbs. feet.}$$

$$B.M_C \text{ (free span)} = \frac{10^2}{8}[100 \times 0{\cdot}3 + 200 \times 0{\cdot}55]$$
$$= \underline{1750} \text{ lbs. feet.}$$

End Spans.

$$B.M_C \text{ (continuous span)} = \frac{12^2}{10}[100 + 200] \times 0{\cdot}45$$
$$= \underline{1944} \text{ lbs. feet.}$$

$$B.M_S \text{ („ „)} = \frac{12^2}{10}[100 + 200] \times 0{\cdot}7$$
$$= \underline{3024} \text{ lbs. feet.}$$

$$B.M_C \text{ (free span)} = \frac{10^2}{8} \times 300 \times 0{\cdot}55$$
$$= \underline{2060} \text{ lbs. feet.}$$

Harbour at Gdynia.

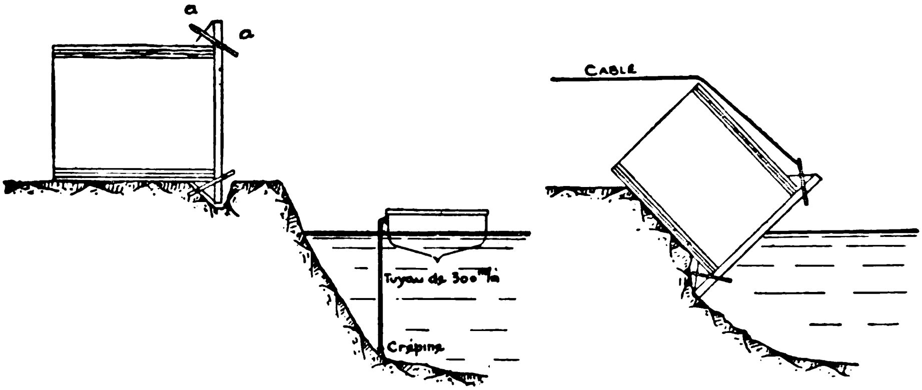
In 1920, during the Russian advance towards Warsaw, the people of Poland realised the need of their country for a free and unobstructed access to the sea, and two years later it was decided to construct a naval and commercial harbour at Gdynia, on the Baltic coast. The contract for dredging was let to a Belgian firm, and that for the reinforced concrete to a Danish firm.

The outer harbour will have an area of 1,440,000 sq. yds., bounded on the north by a mole 2,430 ft. long constructed with timber piles at 16 ft. centres and filled in with stone. The southern boundary will be a mole consisting of a reinforced concrete upper portion on piles and sheet piles. The outer portion of the harbour will be protected by a breakwater resting on reinforced concrete caissons on top of a rubble mound. It is intended to fill these hollow caissons with dredged sand as soon as they are in position. The total length of moles and breakwater will be 9,500 ft.

The naval and mercantile harbours will have areas of 108,000 sq. yds. and 1,330,000 sq. yds. respectively. The present depth of the naval harbour is 19 ft. 8 in. Here, about 390,000 cubic yards have been dredged by a dredger with a capacity of 16,900 cub. yds. in 24 hours.

The reinforced concrete caissons are 56 ft. long, for those with five compartments, and 27 ft. 10 in. high. Concrete with 540 lbs. of cement per cubic yard is employed. The method of launching the caissons is shown clearly in our illustrations, which are reproduced from "Le Constructeur de Ciment Armé." Some difficulty was encountered in towing the caissons to position as the channel tended to silt up and the caissons often grounded.

The caissons were poured with the bottom vertical and close to the bank, which was then undermined by a suction dredger of 325 H.P. with a 12-in. suction pipe.



Method of Launching Caissons.

In the autumn of 1924 four caissons were in position on the north mole, and joined together by filling gravel behind a canvas screen which covered the junction, and cementing this gravel in heights of 3 ft. at a time. The caissons were then filled with sand pumped from the suction dredger and the mass concrete superstructure commenced. Bollards were fixed every 60 ft.

In the mercantile harbour there had been constructed, on December 1, 1926, one caisson with six compartments; two with seven; eight with nine; and seventeen with five. The nine-compartment caisson is 100 ft. long and weighs 1,200 tons.—W. S. G.

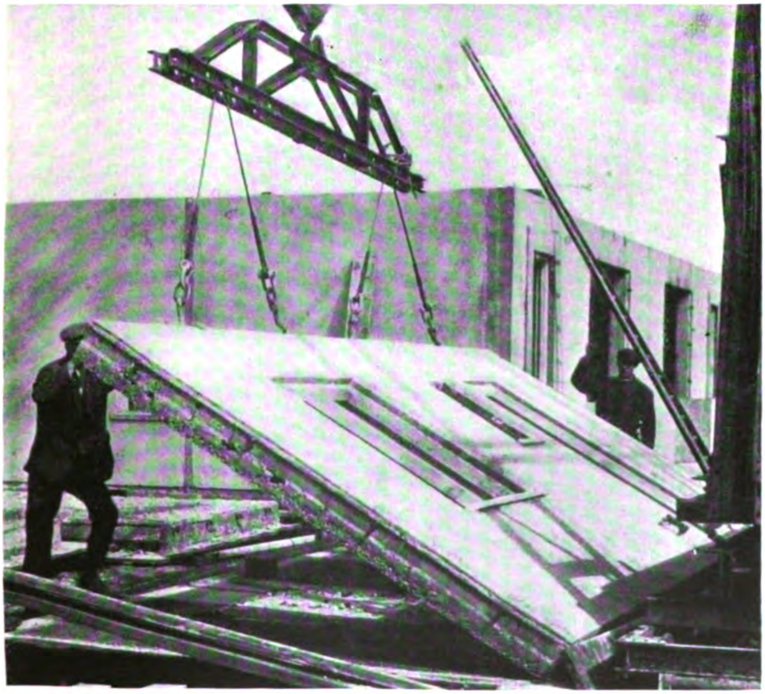
Rapid House Construction.

NOVEL METHODS AT CAMBRIDGE.

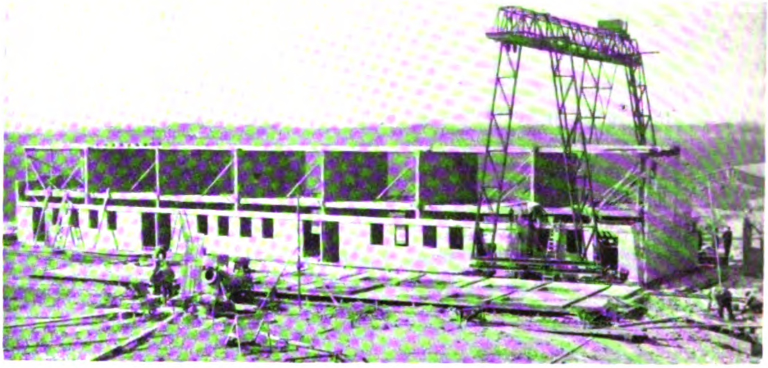
In our issue for March, 1925, we illustrated and described the various methods of concrete cottage construction used in Holland to overcome the shortage of houses. These systems generally were quite novel, and many deputations from this country visited Holland to inspect them. We understand that the Dutch so energetically tackled the housing problem that all arrears have been caught up, and that there is now sufficient accommodation available to meet the demand. As a result, some of the firms operating these systems are seeking contracts outside Holland, and one of them, carrying on business in this country as the British Occident Concrete Construction Co., Ltd., has just completed the erection of thirty houses on the Milton Road site for the Cambridge Corporation, under the direction of Mr. John D. Bland, A.R.I.B.A., Housing Architect to the Corporation.

In the " Occident " system, the walling is pre-cast in large sections and placed in position by a transporter crane. The cost of this plant and its erection is a fairly expensive item, and is only justified on schemes comprising a large number of houses on one site, but on large estates the system has considerable possibilities of economy. Beyond the crane, the expenditure on plant is very small. A narrow-gauge track is laid each side of the site, and on this the transporter is erected so that it travels over the site of the houses to be erected and can pick up pre-cast slabs from outside the track and place them in any position inside the tracks. A similar method of erecting concrete houses by the use of large slabs was used in Liverpool several years ago, but without the transporter crane used in this system.

At Cambridge, each pair of houses consists of fourteen slabs ; the front and

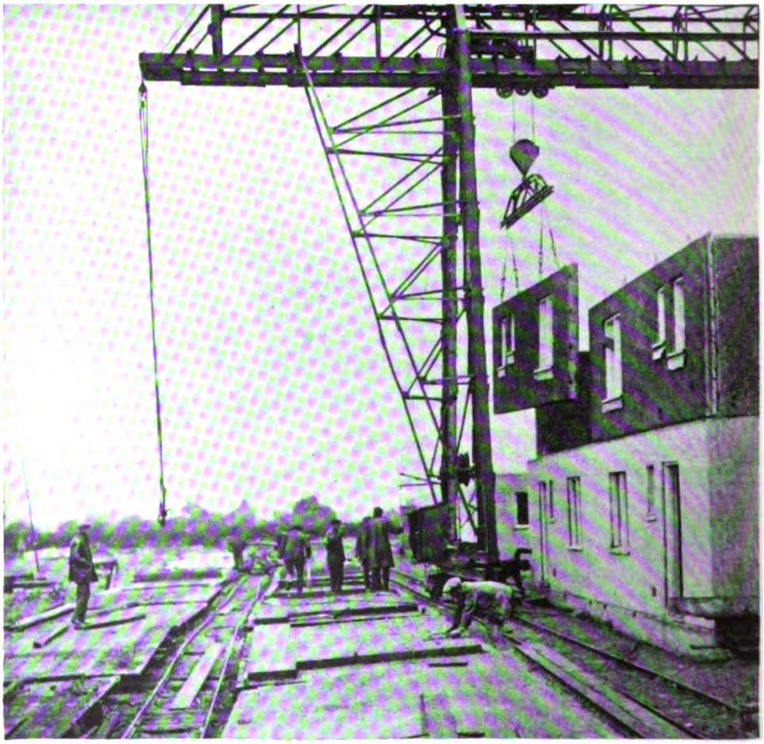


Lifting Slab from Moulding Platform.



Houses in Course of Construction.

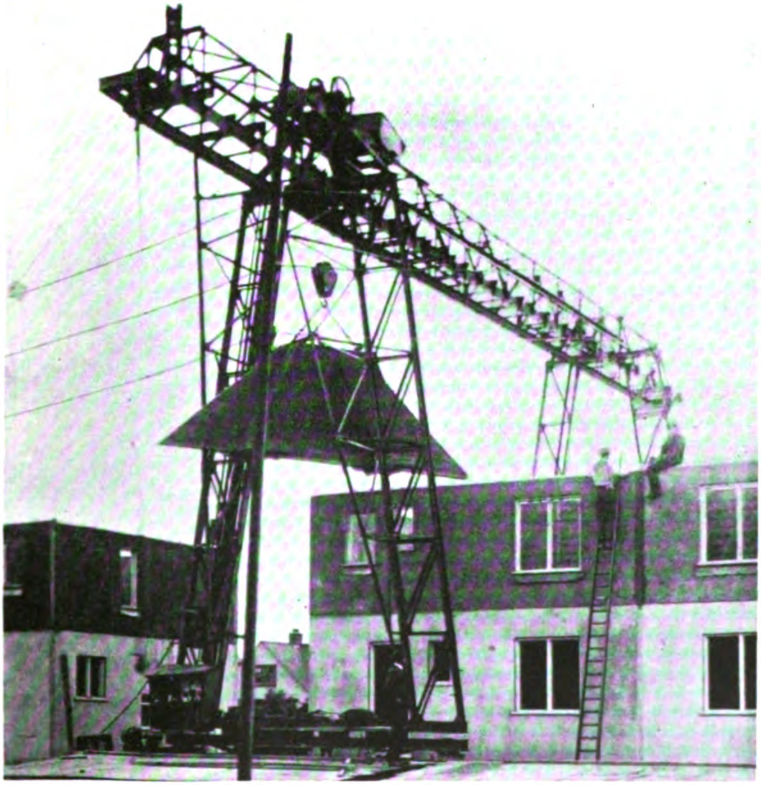
back of each house is made up of two slabs, one for the ground floor and one for the upper story (eight slabs in all for the front and back walls of the pair); the end walls of the pair are formed of two slabs, one for the ground floor and one for the upper floor; while the party wall to each floor is pre-cast as one slab.



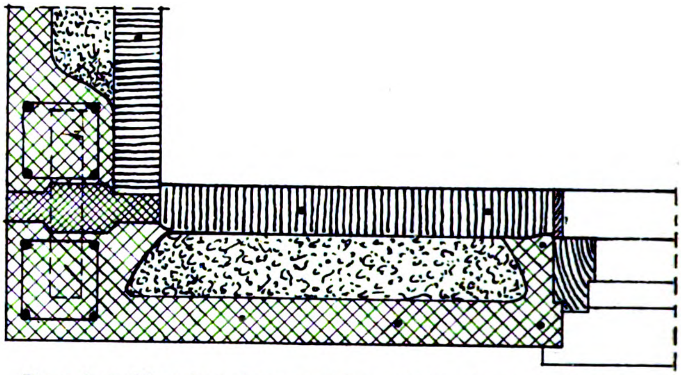
Lifting Slab for Upper Story.

These slabs are moulded on wood platforms beside the site of the house of which they are to form part. Window and door frames are placed in position before concreting commences so that the labour necessary after the walls are erected is reduced to a minimum and at the same time the woodwork is securely fixed in the wall.

The fact that these slabs are cast horizontally gives almost unlimited scope for using different concretes without the expensive shuttering necessary when different mixes are poured vertically. In this system breeze concrete is used for the inner face and ballast concrete for the outer face. The slabs are made with the inner face down. Two inches of 1 : 7 breeze concrete are first spread over the platform ; next is placed 3½ in. of breeze without cement or other binding agent ; and finally a 2-in. layer of 1 : 4½ ballast concrete to provide a weatherproof external face. It is claimed that a wall of this type has three times the insulating properties of a brick wall of the same thickness, and that it has high sound-resisting properties. The breeze concrete inner face prevents condensation, and forms an excellent key for plaster ; it is found that a skimming coat only is necessary to give satisfactory results. The core of loose breeze or other filling fulfils the same function as a cavity, but is claimed to be more efficient than a hollow space in maintaining an equable indoor temperature. The outer layer of ballast concrete makes the wall weatherproof, and the fact that this is cast uppermost on the platform allows it to be readily surface treated. The practice is to scrub this surface about 24 hours after it has been poured in order to expose the aggregate, and the effect

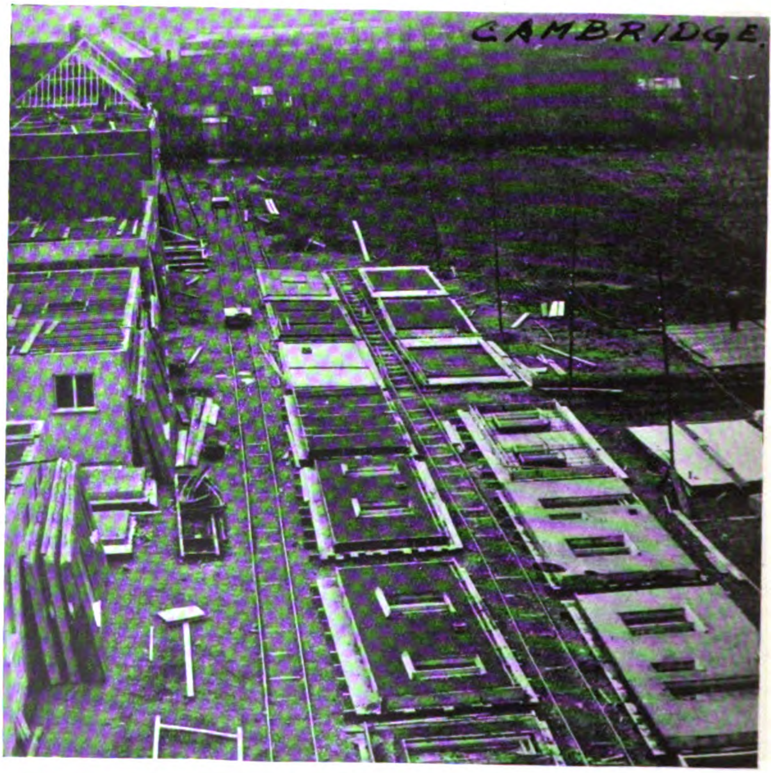


Lifting a Large Flue Section.



Drawing Showing Composition of Weatherproof Wall.

Outer Layer 1 : 4½ gravel concrete ; core of loose breeze ; inner layer 1 : 7 breeze concrete.



Slabs Moulded on Platforms.

Completed Houses.

thus produced on these houses at Cambridge is quite good.

At the corners and at window and door openings the loose breeze core is replaced by ballast concrete, so that at these places there are gravel concrete piers 5½ in. thick to give added strength to the structure. At certain horizontal lines, such as the top of the slab, over window openings, etc., the loose breeze is also replaced by ballast concrete, so that at intervals both vertically and horizontally there are piers and rails of strong concrete, which are reinforced with steel rods.

Usual practice is to use this type of wall for both lower and upper stories, but as the upper part of these houses was to be tile-hung, and there was thus no need for the weatherproof face to the slabs, breeze was used throughout for the walls to the upper stories.

When the slabs are poured, iron rods with hooks at the end are embedded in the concrete for lifting purposes, and when they have hardened they are lifted by the crane and placed in position. With ordinary Portland cement the slabs are left ten days to harden, but a Cambridge rapid-hardening Portland cement was used with the result that it was possible to hoist these large slabs two days after casting, a tribute not only to the cement but also to the strength of the slab.

The first slab erected for each pair of houses is held in position by struts until a slab is placed at right-angles, when the system of interlocking lugs by which the slabs are connected is sufficient to hold them vertical without other support. The lower slabs are bedded in mortar on the footings, while a bed of mortar is placed on the top of these slabs to receive the slabs forming the upper story.

Partition walls are cast in one piece on a platform and hoisted into position in the same way. These are only 2-in. thick of breeze concrete for the upper floor and 4½ in. for the ground floor, and a moving platform is used to prevent breakage during erection. As much as possible of the concrete work is pre-cast and hoisted in this way; on p. 585 is seen a large precast unit to take eight flues. Floors and roofs are built of wood in the usual way, as it is found that concrete offers no economy in this direction when applied to this type of construction.

The contract price for these houses, which have a floor area of 937 superficial feet, is £475, which was considerably lower than competitive tenders for other methods and materials. The appearance of the houses leaves little to be desired, the red tiles to the upper story contrasting well with the ground floors; the scrubbed surface of the lower stories has a very pleasant appearance, enhanced by the use of large aggregate which is exposed on the face of the wall in various shades relieving the general greyness.

Fusing of Concrete.

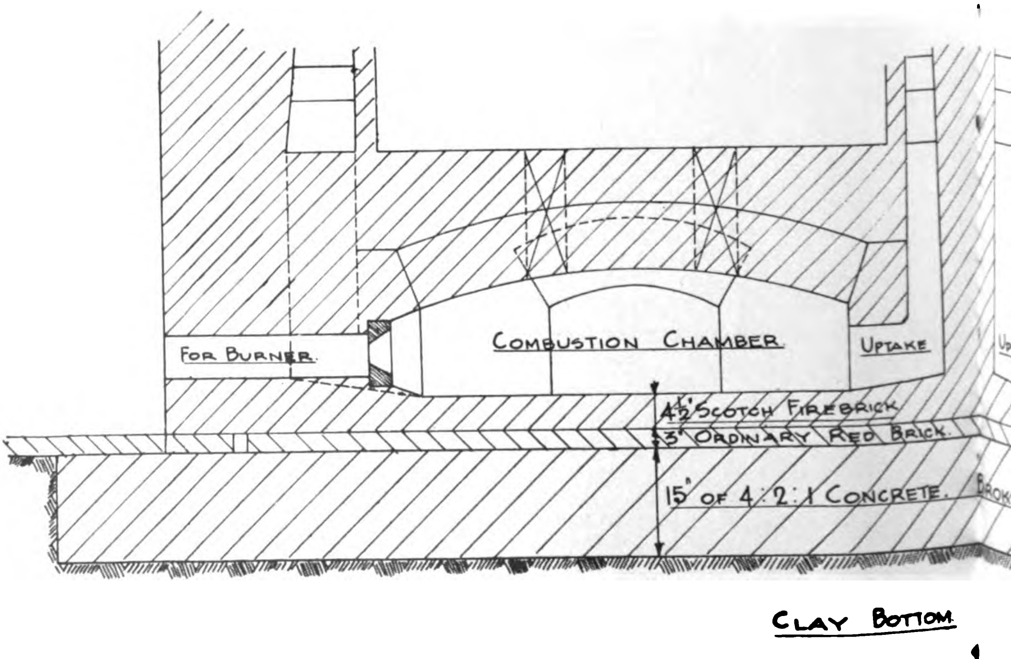
By **A. E. PERKINS.**

WHILST there are many instances on record of the spalling and cracking of concrete under heat or actual fire, there appears to be little information to be obtained in respect of the fusing of concrete. A recent experience of the writer's may, therefore, prove interesting to those connected with furnace design, etc.

Some little time ago the writer was engaged on the construction of an underfired muffle furnace, oil-fired, the combustion chamber as shown in diagram. The design of the foundation, as shown, was based on the generally accepted assumptions. In fact, according to Professor W. Trinks, of the Carnegie Institute of Technology: "For furnace foundations concrete is the most commonly used material and ordinary red building bricks form an excellent material for furnace foundations; red bricks will withstand a higher temperature than concrete, without disintegration."

After the furnace had been in commission only three weeks it was noticed that the centre wall was cracking and settling. It was at first thought that some local settlement of the supporting earth under the concrete foundation had taken place, but as the cracking and settlement continued it was decided to investigate. On the demolition of the furnace down to the concrete supporting raft, it was found that this raft had fused into a mass of solid black-green glass, which showed every evidence of having been in the plastic state and thus allowed the settlement of the centre wall of the muffle.

A curious point about this phenomenon was that the best glass was found at the ground side of the foundation, viz. the side farthest removed from the heat. The layer of Scotch firebricks was in perfect condition, and as a matter



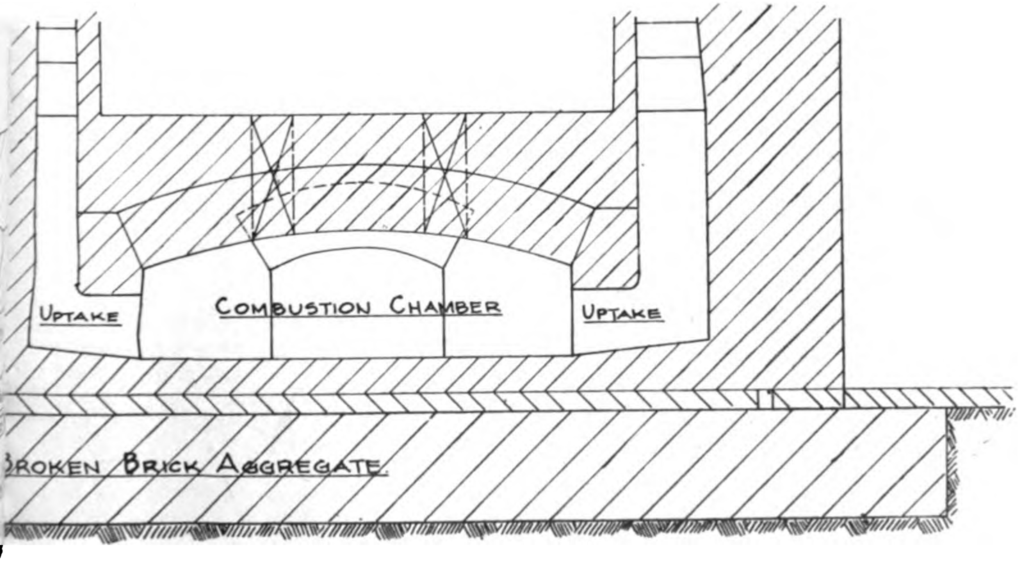
of fact most of the bricks were used again in reconstructing a new furnace. The ordinary red building bricks, too, were in nearly every case quite good, making the occurrence the more mysterious. As has already been stated, the combustion chamber was oil-fired and the temperature therein, as taken by the optical pyrometer, was 1,610 deg. C., 2,930 deg. F. The firebricks used on the bottom of the combustion chamber were on refractory test, Seger cone, 35, 1,770 deg. C., or 3,218 deg. F.

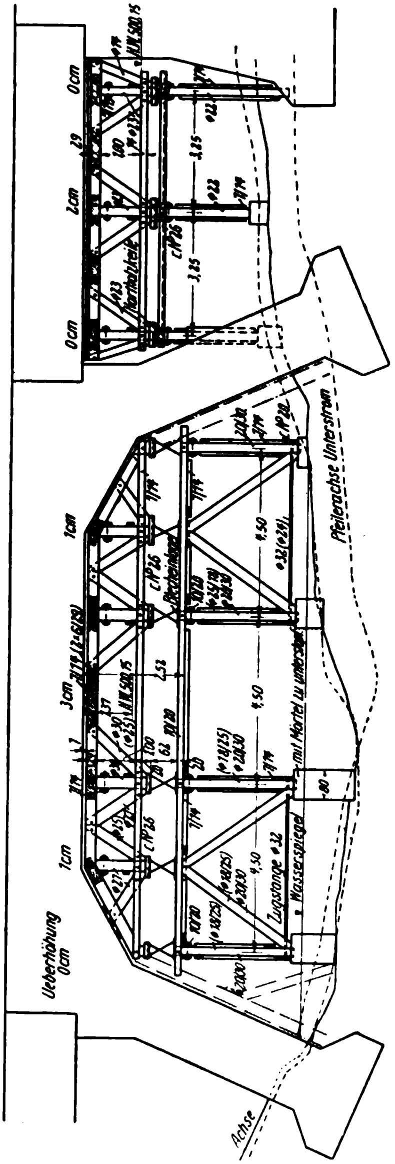
The black-green glass was found to be the most readily fusible part of the concrete base and fused at approximately 930 deg. C. This temperature must therefore have been reached through the firebrick and layer of red brick. There appears to be little or no data relating to the heat transference from brick to concrete to earth, but it would certainly appear that the above-mentioned temperature, at least, had been obtained.

The chemical analysis of two samples of the concrete glass is given below:

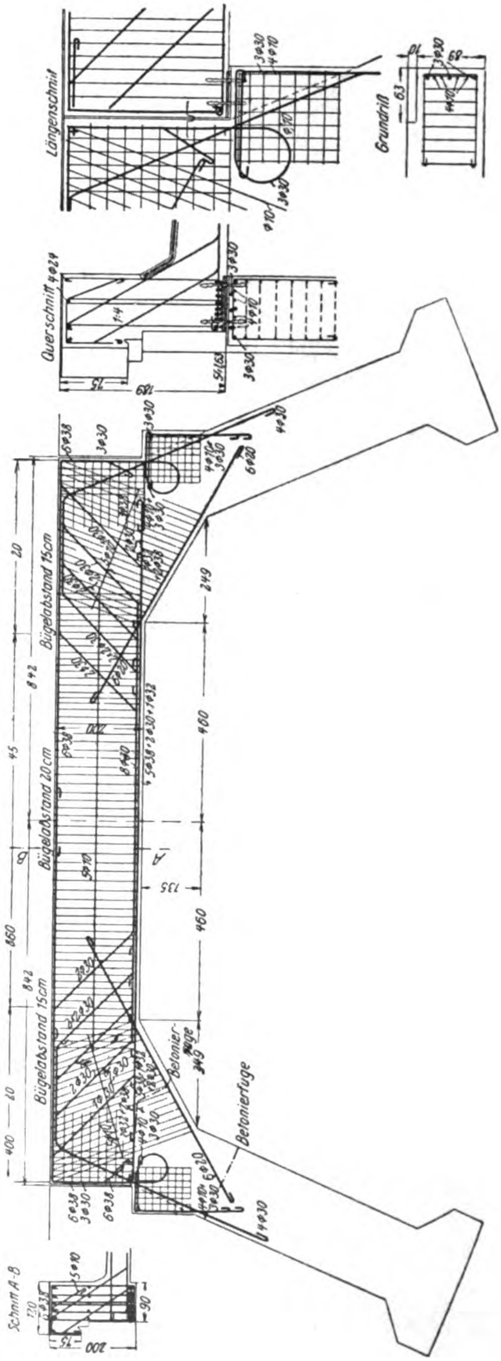
	(A)		(B)	
Silica	63·08	per cent.	60·38	per cent.
Alumina	10·87	,,	11·32	,,
Iron oxide	8·89	,,	8·5	,,
Lime	15·76	,,	17·72	,,
Magnesia	1·37	,,	1·85	,,
Sulphuric anhydride	0·12	,,	Tr.	
Gain on ignition	0·3	,,	0·48	,,
Copper	—		Tr.	
Silica ratio	3·2	,,	3·03	,,

The reconstructed furnaces were built with air ducts interposed between the combustion chamber and the concrete base and have given entire satisfaction.





Formwork.



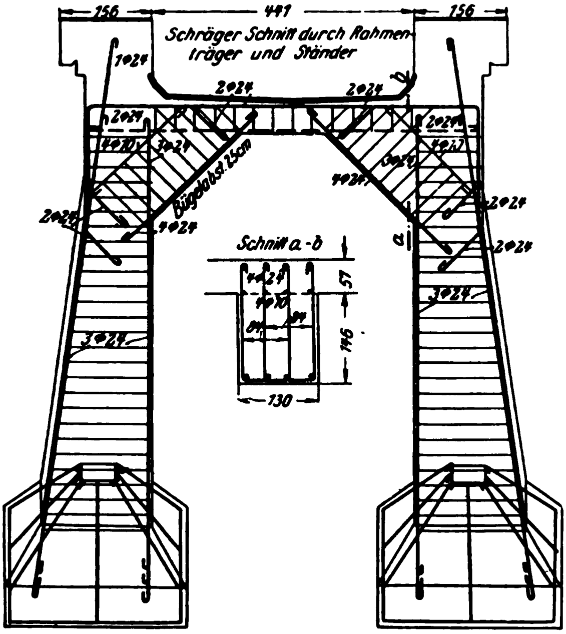
Reinforcement of Frame.

An Unusual Type of Bridge. (*See p.* 591.)

An Unusual Type of Bridge.

LONG article by K. Schaechterle describ- ng the design and construction of the ew Murg bridges which are of a type hat we do not remember having seen reviously, and which has some interest- ng features, appeared recently in " Beton . Eisen."

These bridges were erected in the most icturesque parts of Savoy, connecting he Wurtemburg State Railway terminus ith that of the Bavarian State Railways. einforced concrete was selected instead f steel, which was considered unsuitable in such a locality. Owing to the limited headroom between rail and flood-levels, a masonry arch was out of the question.

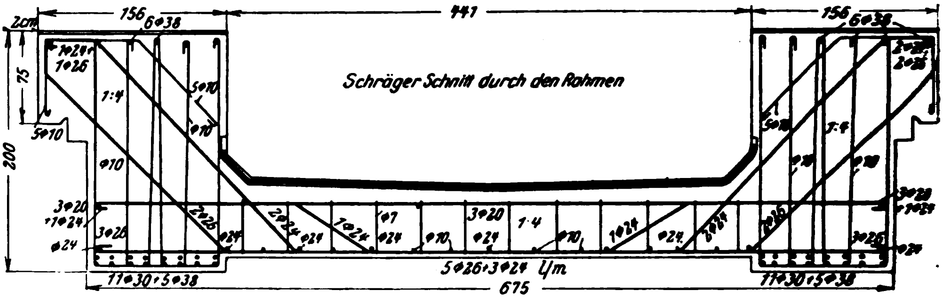


Cross Section.

The bridge illustrated crosses the river on a skew of 50 deg. and on a gradient of 1 in 400 at a place where the river has a very high velocity sufficient to make the cost of river piers prohibitive. As the banks consisted of very good rock, an arch in concrete might have been selected, but this would have had the disadvantage of cutting down the waterway in times of flood. A single span of nearly 100 ft. would have been required if a beam design without piers had been chosen. This is, of course, beyond the limiting span for the beam type of bridge in reinforced concrete when carrying such heavy loads as had to be provided for. The type decided on, with sloping piers rigidly connected to the middle span and two freely supported side spans, has proved satisfactory. It has been possible to make the middle span only 45 ft. in length.

The limited headroom had another influence on the design of the middle span; the span could not be designed as a double-ell beam with a compression head—a type corresponding to the steel deck plate-girder—and the girders had to be constructed as " through-girders " with wide heads to take the compression.

The span of the middle frame is 66 ft. at foundation level, and its height 22 ft. 8 in. The floor is 14 ft. wide and 19 in. thick. In calculating the sections



Cross Section.

required, a loading of 20 tons on each of six axles was taken and a temperature range of 15 deg. C. Wind and lateral stresses were taken care of by the introduction of stiff haunches at the upper ends of the transverse frames. The frame being three-fold statically indeterminate, the stresses were computed by the method of elastic weights, and limited to 430 lbs. per square inch in the concrete and 10,600 lbs. per square inch in the steel.

The concrete slab was rendered with cement mortar on which two layers of tarred cardboard were laid. The latter were protected by a coat of cement mortar containing a light mesh reinforcement. Drainage of the slab was provided through iron pipes cast in the concrete.

To allow for expansion of the side spans a sliding plate was fixed to the lower side of the beams and a similar plate on the support.

The lower formwork was supported on blocks of concrete resting on the river bed. The junction between upper and lower forms was made by means of jacks.

Granite concrete, gauged rather wet, was used for the superstructure and a poorer mass concrete for the abutments. —W. S. G.

Drawing Office Practice.

Recommendations for British standard drawing office practice, dealing with a standard procedure for submitting drawings, tracings and blue prints to be adopted by manufacturers and contractors, have just been published by the British Engineering Standards Association. This publication is of considerable interest to those engaged in industries where drawings are used. The Committee state that considerable care has been expended in its preparation, so that no hardship should fall on any firms should the recommendations contained in the report not be in strict accordance with their usual practice. To cover this contingency, a note has been included which suggests that purchasers should not enforce the manufacturer or contractor to make new drawings to comply with the B.E.S.A. recommendations if the latter already has old drawings and tracings in stock which would serve the purpose.

The scope of the report covers the overall sizes of tracing cloth and paper, position of drawing number, date and name, indication of scale, method of projection, types of lines and writing, dimension figures, relative importance of dimensions, indication of material on drawings, screw-threads, flats and squares and tapers, together with explanatory diagrams. Any special convention relating to one particular industry had to be avoided if the report is to be generally adopted, and for this reason many abbreviations and conventions common to one or more, but not common to all, have had to be dispensed with. Copies of the Report may be obtained from the British Engineering Standards Association, price 2*s*. 0*d*.

A Pre-Cast Concrete Works.

We recently had an opportunity of visiting the works of the Wharf Lane Concrete Co., Ltd., of Ilminster. This firm now has a considerable output of architectural cast stone, walling slabs, garden ornaments, fireplaces, and similar high-class work, as well as the ordinary run of concrete blocks, slabs, fence posts, troughs, pipes, etc. Ham Hill, Doulting, and Portland are the stones of the district, and it is of these stones, principally the former, that the firm's products are mostly made.

The principal building is that used for the moulding of high-class cast stone. The woodworking and plaster modelling shops are partitioned off at one end, the large centre portion is devoted to benches for casting, while the crushers and mixers are at the other end. All the benches are made entirely of concrete, with tops about 3 inches thick, which cost less than wood. As much as possible of the placing, stripping of moulds, etc., is done on these benches, of a convenient height in order to avoid the unnecessary fatigue caused by stooping when the work is done on the floor.

Sand Moulds.

A general view of this shop is shown in *Fig.* 1. In the left foreground a sand mould for a curved slab is shown in course of preparation. This is an interesting example of the use of special moulds for special purposes. In this case the stone is to be made with its convex face downwards, the sand being screeded to the shape of the stone by screeds on wood strips worked to the desired curvature; the concrete is then placed on the sand, and the back screeded off to shape.

Concrete Moulds.

A view in the modelling department is shown in *Fig.* 2. This shows the modeller

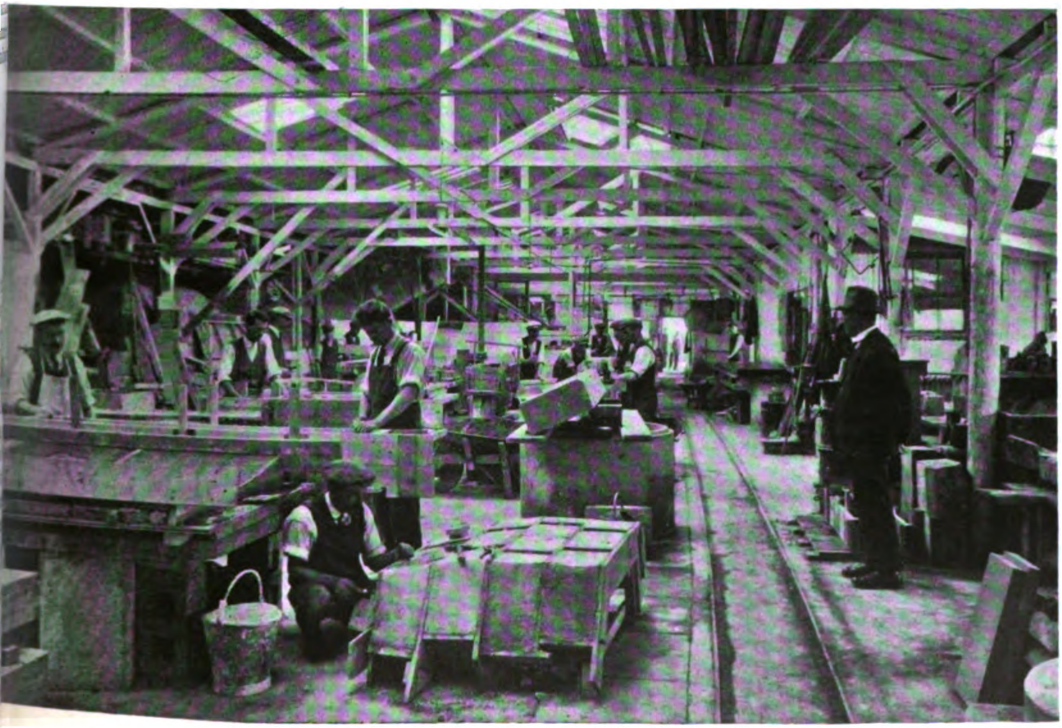


Fig. 1.—Interior of Moulding Shop.

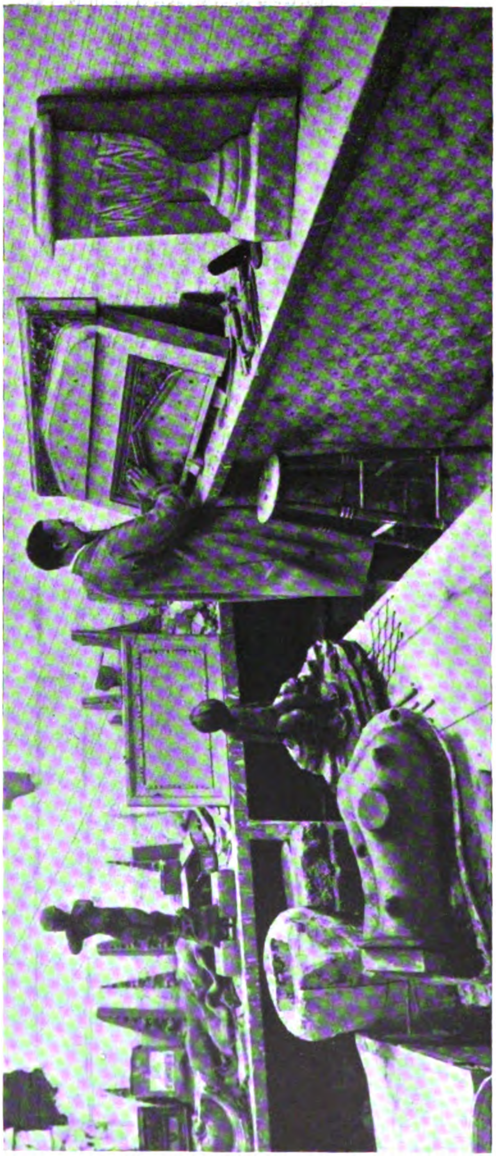
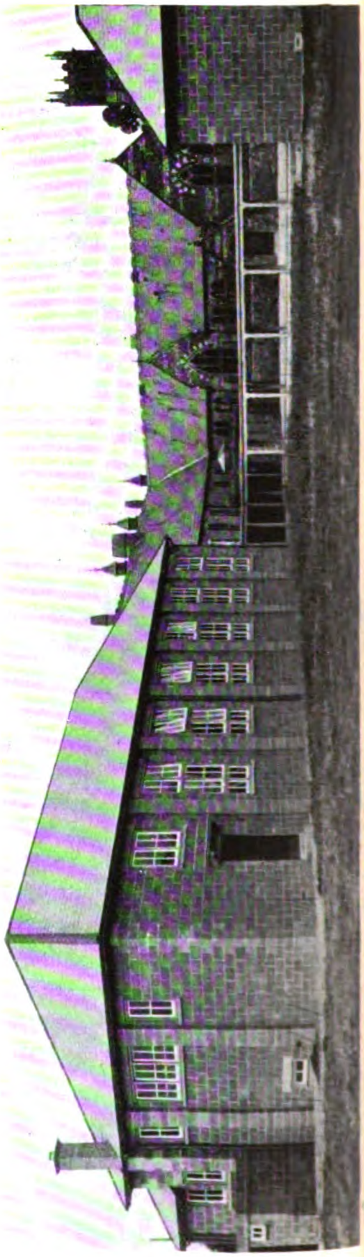


Fig. 2.—Modelling Shop.



at work on a clay model of the upper section of a fireplace, above which is a concrete mould made from a similar model. The firm has for some years specialised in concrete fireplaces, and has been very successful in producing good designs by slightly modernising Tudor patterns.

Moulding in concrete and cement moulds is a novel feature which the staff has worked out and developed to such an extent that they are used almost exclusively for repetition shapes, such as these ornamented fireplace sections, balustrade columns, sundial pedestals, garden ornaments, columns, etc. Not only is their life practically indefinite, but for many purposes they are actually easier and cheaper to make than plaster or wood moulds. In most cases these concrete moulds are cast direct from the clay model; that is, forms of a height corresponding to the desired thickness are securely fixed around the model and the concrete poured in, the model being previously shellaced and oiled to prevent

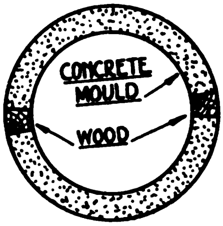


Fig. 4.—Concrete Mould for Column.

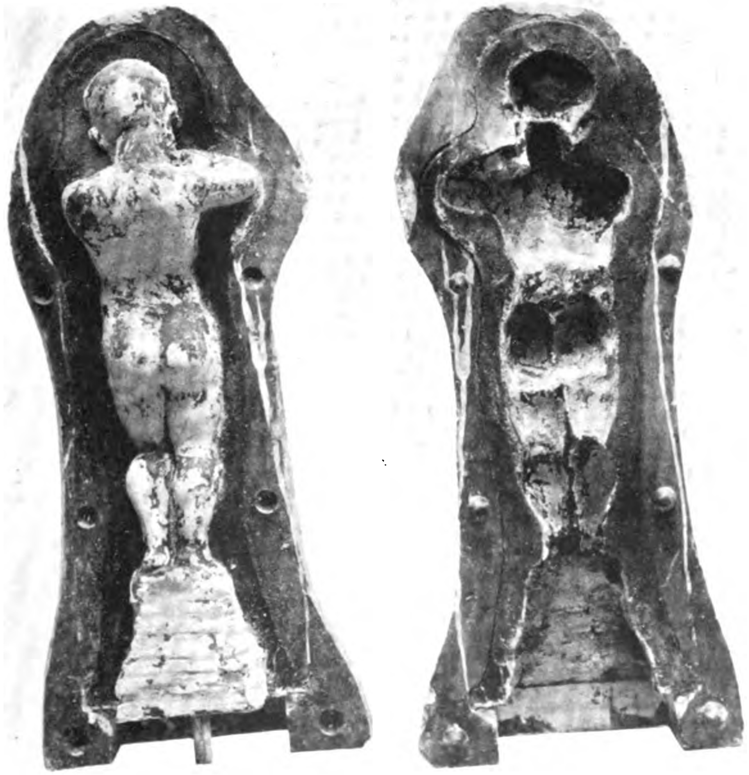


Fig. 5.—Gelatine Mould.

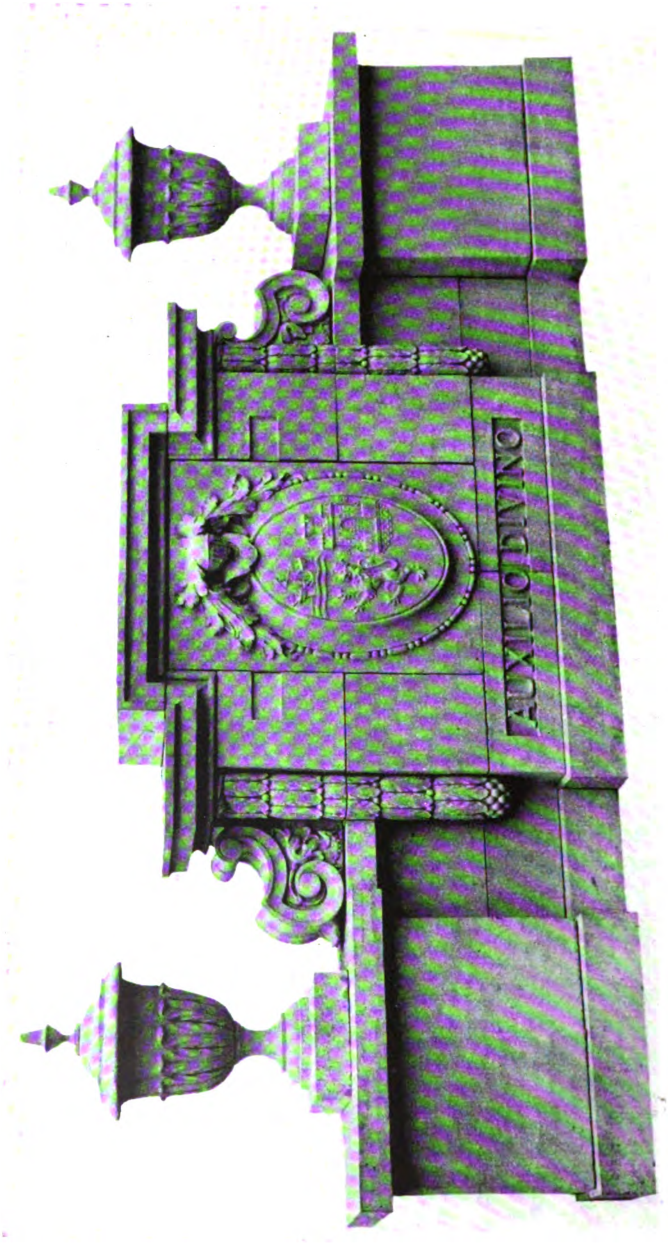


Fig. 6.—Ornamental Piece for Totnes Secondary School.

sticking. The mixture used for the moulds depends upon the amount of detail to be reproduced, as obviously the sand content, if any, must be very fine if a clean-cut mould is required of small detail; the mix must also be sufficiently plastic to fill all the details without tamping, as tamping would spoil the model.

According to their shape, these concrete moulds are used either as complete moulds or as face-plates in wood moulds. In the case of the fire-place moulds, the sections are placed in the bottom of a wood frame which is filled to the desired thickness. For such articles as balustrade columns the moulds are made in two sections and fitted with projecting lugs to take bolts; for vases they are made in two or more sections; they are in fact made on exactly the same principle as iron moulds.

Columns of any height are made in concrete moulds, both straight and with entasis; in these moulds, two strips of wood are used vertically to complete the circle in order to ensure that the inner face of the mould shall be a true circle, and that there shall be no fins on the column caused by failure of the concrete sections to fit exactly (*Fig.* 4). A power-driven machine is used for turning columns and other circular work.

Gelatine Moulds.

A typical gelatine mould is seen in *Fig.* 5, which shows to the left a section of the mould with the concrete figure not yet removed, and to the right the other half-section of the mould. In making these gelatine moulds a clay model is first covered with clay to a thickness of an inch or so, and surrounded with a plaster casing. The plaster is removed and the clay cleaned away from both model and plaster, so that when the plaster casing is placed around the model again, the space previously occupied by the clay is available for the gelatine.

In the case illustrated, the gelatine (which is similar to thin glue heated in the usual way in a double vessel) is poured from the bottom into the space between the model and the plaster casing. After the glue has set, the casing is removed, the glue cut in two sections and replaced in the plaster casing, and the model put at one side for future use. To make a concrete article from this mould, the two plaster casings containing the sections of glue mould are fitted together and held in position with wire or string, and concrete of a thin consistency poured in and stirred with a metal rod.

Fig. 6 is a particularly fine piece of work just completed for the Devon County

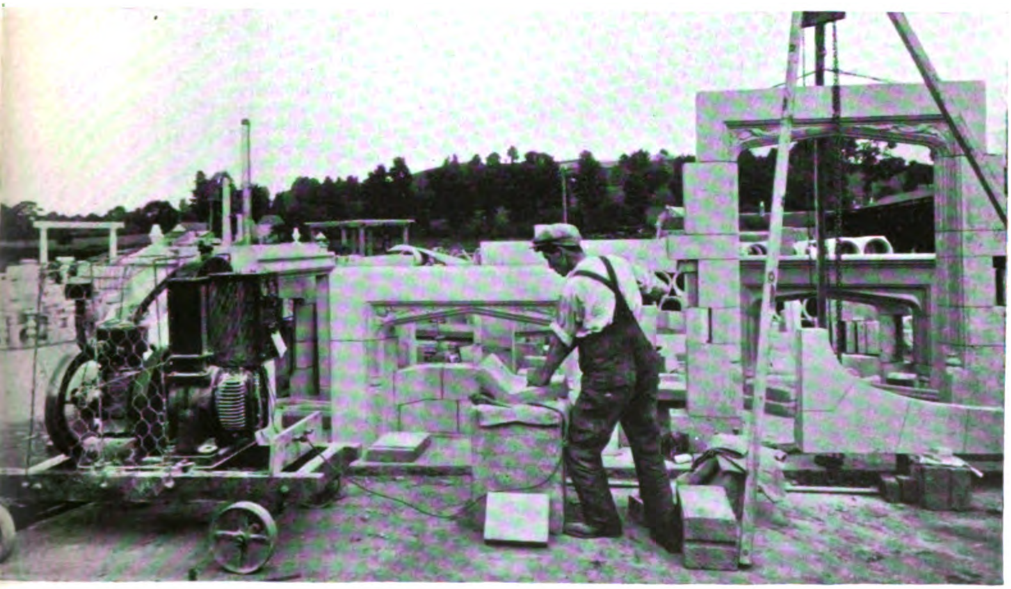


Fig. 7.—Tooling Surface of Fireplace Slab.

Council. It is one of a series of ornamental pieces, in cast Portland stone, for erection over the entrance to Totnes Secondary School to the specification of Mr. Percy Morris, County Architect of Devonshire. The work was carried out in wood moulds for the plain sections and plaster moulds for the ornamental sections.

Surface Tooling.

As already stated, the bulk of the stone is a reconstruction of Ham Hill stone, which particularly lends itself to a tooled surface. This stone is far more pleasing with the slightly rough texture left by the chisel than when polished or rubbed, and for this reason most of the products of the Company are tooled on the surface. For this purpose an electric surfacing machine is used mounted with its power unit on a wheeled truck so that it may be readily moved about the yard; the machine is taken to the work instead of taking the stone to the machine. Any type of tool may be fitted to the machine, which is very effective and performs its task with remarkable speed. In *Fig. 7* it is seen in operation surfacing a fireplace slab with the tool. This takes a slight thickness from the surface, leaving a face which is quite indistinguishable from hand-tooled natural stone. This machine is also used for vibrating special castings, and is very effective with two hammers and their many slight blows. According to the purpose for which they are required, the slabs consist of crushed stone aggregate, or a facing of crushed stone with a backing of gravel or clinker concrete.

Slabs.

"Semi-dry" concrete is never used except in the case of such goods as clinker slabs. When faced slabs are made by machine they are always made face-down, using a wetter mix for the facing; the excess water is absorbed by the dryer backing when pressure is applied, so that a rapid output is obtained with no loss of strength in the face concrete.

The use of these plain slabs is admir-

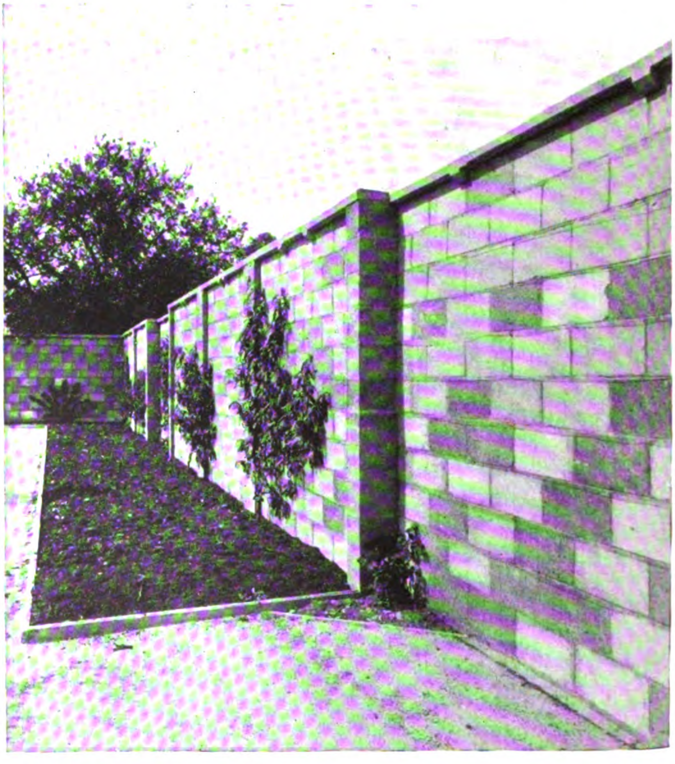


Fig. 8.—Slab Wall and Coping.

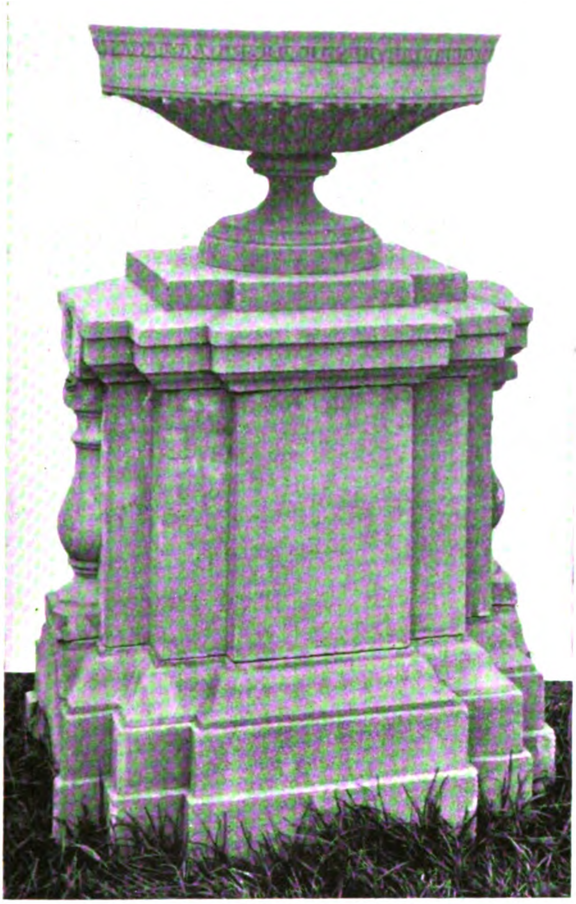


Fig. 9.—Balustrade Pier.

ably illustrated in the photograph of the extensions to the Ilminster Endowed Schools (Mr. A. J. Pictor, architect) (*Fig.* 3). The new work has been made specially to match the existing buildings, and neither in colour nor texture can the new be distinguished from the old. By slight alterations in the mix with different batches a delightful variation in the colour of the slabs has been produced thus avoiding any monotony and ensuring that the new buildings will tone down to the same appearance as the old.

The use of slightly differing mixes to produce a large wall area without monotony is also demonstrated in *Fig.* 8, which shows a garden enclosure wall. The walling is in gravel concrete in which the slabs made from slightly different batches of concrete are mixed together in construction.

A point of interest in this wall is that although 10 ft. high it is only 4 in. thick, dimensions which could not have been adhered to if brick had been used. The set-back of sections of the face of the wall is obtained simply by grooving the edges of one panel into the piers near the front and the next panel nearer the back of the pier. The coping has projections cast on it at intervals in the form of corbels; although these do not fulfil the usual function of corbels, namely, support the stone resting on them, they serve a useful purpose in tying the top of the slabs and also add to the appearance of the wall.

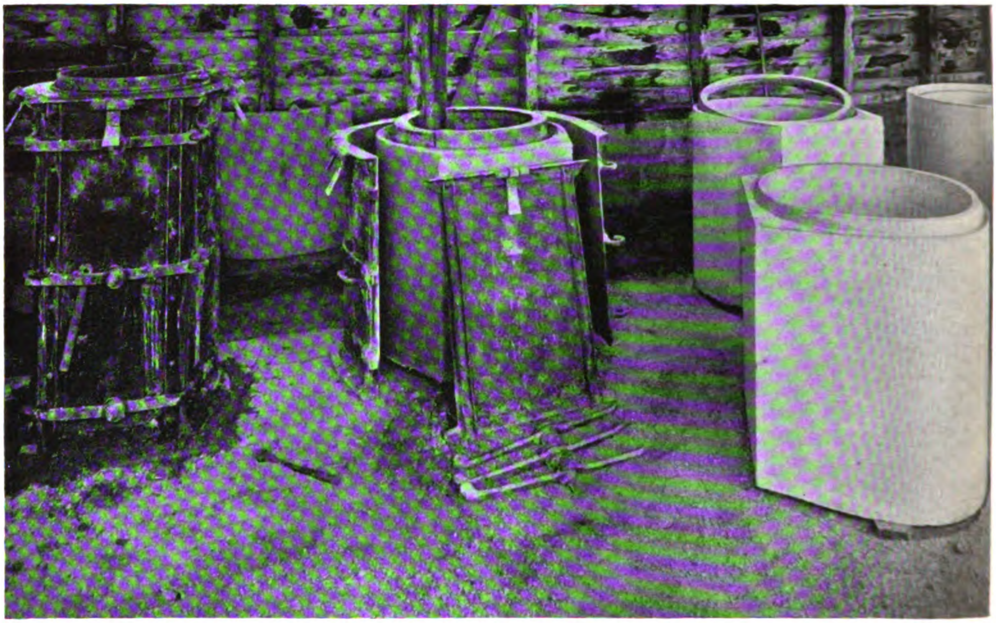


Fig. 10.—Pipe Moulds.

An example of the ornamental work produced by the firm is shown in *Fig.* 9, a well-designed balustrade pier surmounted by a vase, carried out in cast Ham Hill stone.

Sheet steel moulds, made to a special design, are used for making posts, the feature of which is the fact that the sides are slightly sprung so that when the holding clamps are knocked away the sides of the mould automatically spring apart and release the post.

Pipes.

Pipes and tubes are made in all sizes from 9 in. to 42 in. A simple type of mould is used (*Fig.* 10), which can be set up and released by one man for the largest tube. The type of mould is shown in the illustration. The outer core is in three sections held together by the three clamps shown in the foreground. The inner core consists of two large sections and a slightly tapered sword-piece, which is withdrawn without disturbing the newly-placed concrete by a special device in the form of a light frame containing a screw; this is placed on the top of the mould, a hook on the end of the screw passed through a hole in the top of the sword piece, and the latter slowly raised by turning the screw.

Curing.

Rapid-hardening Portland cement is used for practically the whole of the output. This not only expedites the progress of manufacture, but also considerably increases the strength of the concrete. In passing, it is interesting to note that Mr. Hutchings (the founder and a Director of the firm) was one of the pioneers of steam curing in this country, but owing to the introduction of rapid-hardening Portland cement the one-time steam chamber has now become a store-room; in Mr. Hutchings' opinion, there is no need for steam curing in our climate now that concrete will reach practically maximum strength in three days when made with rapid-hardening Portland cement and in 12 hours when made with aluminous cement.

Curves for Double Symmetrical Reinforcement.

By **A. G. C. FANE, M.Inst.C.E.**

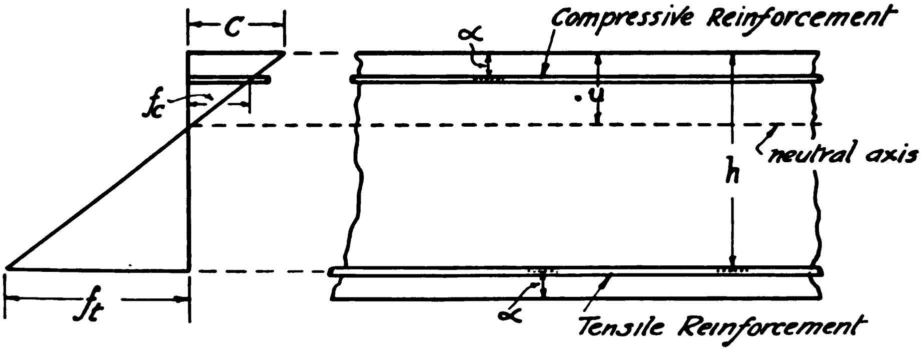
If double reinforcement has to be used the necessary calculations are somewhat long and complicated. For this reason certain assumptions as to the position of neutral axis are frequently made, and these assumptions affect the accuracy of the result to an appreciable extent.

These curves have been made so as to save the trouble of making the calculations, and at the same time to avoid any inaccurate assumptions.

The mathematical treatment of the case by Mr. F. H. Burkitt is given below. From this the author has made the tables and plotted the curves by working out examples and plotting results.

These curves are only designed for use with symmetrical reinforcement; that is, the reinforcement at top and bottom must be similar.

Consider the beam below:—



b = breadth of beam.
c = maximum compressive stress in concrete.
f_c = maximum compressive stress in steel.
f_t = maximum tensile stress in steel.
u = distance of neutral axis from compressive edge of beam.
h = effective depth of beam from compression surface to centre of tension bars.
a = distance from surface of beam to centre of reinforcement.
A = cross sectional area of steel in tension *or* compression.

then

$$f_t = 15c\frac{h-u}{u} \quad \ldots\ldots\ldots \quad (1)$$

$$f_c = 15c\frac{u-a}{u} \quad \ldots\ldots\ldots \quad (2)$$

$$\therefore f_t - f_c = \frac{15c(h+a-2u)}{u}$$

$$\therefore A(f_t - f_c) = \text{compression taken by concrete,}$$

$$= \frac{cub}{2},$$

$$\therefore \frac{cub}{2} = \frac{15c(h + a - 2u)}{u} \times A,$$

$$\therefore A = \frac{u^2b}{30(h + a - 2u)} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Moment of resistance about neutral axis :—

$$\frac{cub}{2} \times \frac{2u}{3} + Af_c(u - a) + Af_t(h - u),$$

$$= \frac{cu^2b}{3} + \frac{u^2b}{30(h + a - 2u)} \times \frac{15c}{u}(h^2 - 2hu + u^2 + u - 2ua + a^2)$$

$$= cub\left[\frac{u}{3} + \frac{1}{2(h + a - 2u)}\left\{h^2 + a^2 - 2u(h + a) + 2u^2\right\}\right]$$

$$= \frac{cub}{6(h + a - 2u)}\left\{2u(h + a) - 4u^2 + 3(h^2 + a^2) - 6u(h + a) + 6u^2\right\}$$

$$\therefore c = \frac{6M(h + a - 2u)}{ub\{2u^2 - 4u(h + a) + 3(h^2 + a^2)\}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

If we have a beam as above in which we have assumed certain dimensions for h and M, we have to solve the lengthy equation 4 for an assumed position of u, and then to repeat this by trial and error method to get a suitable c. In order to avoid these troublesome calculations four typical beams have been worked out for $h = 10$ in. with different values of a.

One of these types (shown thus—— – – ——was of the following dimensions

$h = 10$ in.
$a = 1$ in.
$b = 1$ in.
then if $f_t = 16{,}000$ lbs. per sq. in.
$c = 600$ lbs. per sq. in.

For a beam without compressive reinforcement we know that

$u = 0{\cdot}36h$ and
a (lever arm) $= 0{\cdot}88h$
$\therefore M = 600 \times 0{\cdot}36 \times 8{\cdot}8 = 9{,}504$ inch lbs., and
$A = 0{\cdot}00675 \times 10 = 0{\cdot}0675$ sq. in.

Now consider the same beam with double symmetrical reinforcement. Assume $M = 9{,}504$. Work out from formula 4 the value of c for a series of values of u as shown in Table 1(A) (page 607). The value of c in each of these cases found by formula 4 is given in column 4.

Now find A by formula 3 for each value of u. The results are given in column 5. Then find f_t and f_c by formulas 1 and 2 for each value of u. The results are given in columns 2 and 3 of Table 1(A).

Now we have complete tables giving the value of all unknowns for this type of beam in which $a = 0{\cdot}1h$, for all values of u, for a bending moment of 9,504 in. lbs. All these beams are not fully loaded; that is to say, we could have a larger bending moment than 9,504 in. lbs. without getting f_t or c above their safe limits.

Now see Table 1(B) for the same beam. Column 1 gives the same values of u as before; column 2 gives the ratio of u to h. This is wanted for plotting the curves for use of beams of other different heights. For each of these values of u let us bring f_t up to its safe limit, 16,000 lbs. per sq. in.

$f_t = 15c\frac{h-u}{u}$. If we increase f_t in any one beam we do not alter the ratio $\frac{h-u}{u}$

$$\begin{aligned} \therefore\ & f_t \text{ varies as } c \text{ and} \\ & M \text{ varies as } c \\ \therefore\ & M \text{ varies as } f_t. \end{aligned}$$

Thus in the case of $u = 3{\cdot}6$ in., if $f_t = 9{,}414$ lbs. per sq. in., $c = 352{\cdot}99$ lbs. per sq. in. Therefore if we make

$$\begin{aligned} f_t &= 16{,}000 \\ c &= 352{\cdot}99 \times \frac{1{,}6000}{9{,}414} \\ &= 600 \text{ lbs. per sq. in. and} \\ M &= 16{,}153 \text{ in. lbs.} \end{aligned}$$

Thus the values of M and c for $f_t = 16{,}000$ with each value of u found. These are entered in columns 7 and 4 of Table 1(B). The value of A given in column 5 remains as before. Column 6 is r = ratio of area of steel in top *or* bottom reinforcement (not both) to area of concrete.

The safe bending moment for a beam of this size without compressive reinforcement (that is, the normal bending moment) was 9,504 in. lbs., whereas the safe bending moment when $u = 3{\cdot}6$ in. as shown in column $7 = 16{,}153$ in. lbs. Therefore the ratio $\frac{M}{M_n}$ in this case $= \frac{16{,}153}{9{,}504} = 16{\cdot}996$. Similarly the value of $\frac{M}{M_n}$ is found for each position of u.

These tables refer to beams in which the ratio $\frac{a}{h} = 0{\cdot}10$. Similar tables have been worked out for beams in which $\frac{a}{h}$ is equal to 0·125, 0·15, and 0·175.

The curves plotted for each value of $\frac{a}{h}$ are (*a*) curve showing corresponding values of r and $\frac{u}{h}$ (that is, it shows the position of neutral axis for any value of r or vice versa); (*b*) curves of $\frac{M}{M_n}$ for any value of r.

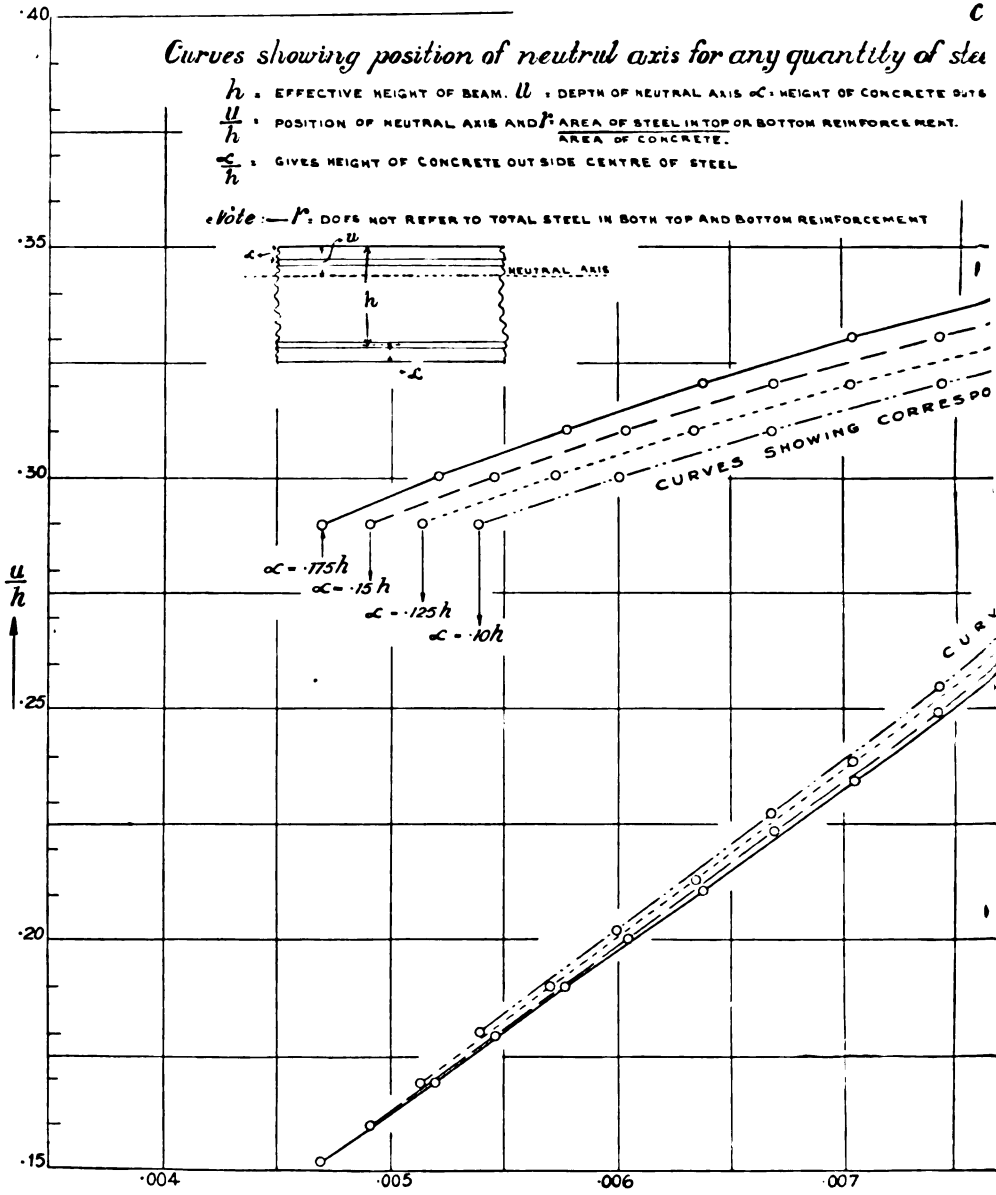
Example 1.—A beam of double symmetrical reinforcement

$$\begin{aligned} h &= 20 \text{ in.} \\ r &= 0{\cdot}009 \\ \frac{a}{h} &= 0{\cdot}15 \end{aligned}$$

(Required to find position of neutral axis and safe B.M.)

DOUBLE SYMMETRICAL REINFO

FOR MODULAR RATIO = 15 AND WORKING STRESSES



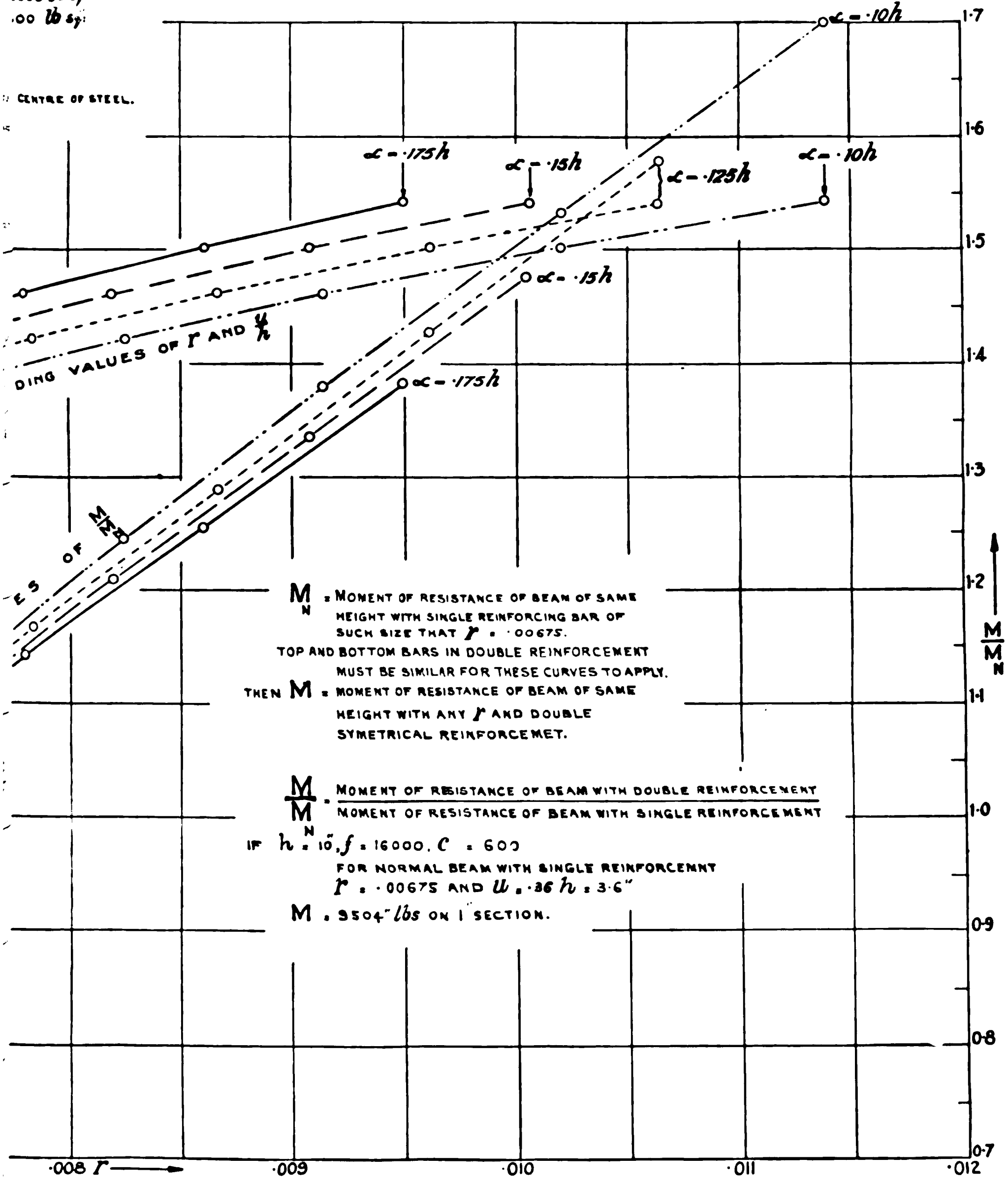
CURVES FOR DOUBLE SYM

EMENT

5000 lb sq

·00 lb sq

CENTRE OF STEEL.



METRICAL REINFORCEMENT.

Follow up the vertical line $r = 0{\cdot}009$ till it cuts the curve shown thus ——— ——— ——— and we get $\frac{u}{h} = {\cdot}3490$ and $M = 1{\cdot}321 M_N$.

For a beam of height $h = 20$ in., if $f = 16{,}000$ $c = 600$ lbs. per sq. in.

$$M_n = \tfrac{1}{2} cu \times a$$

$$c = 600,\quad u = 0{\cdot}36h,\quad a = 0{\cdot}88h,$$

$$M_n = 300 \times 0{\cdot}72 \times 17{\cdot}6$$

$$= 38{,}016 \text{ in. lbs.},$$

$\therefore$ safe bending moment for beam

$$= 38{,}016 \times 1{\cdot}321 = 50{,}220 \text{ in. lbs.}$$

Example 2.—To design a beam—double symmetrical reinforcement—to stand a bending moment of 30,000 in. lbs. per inch section of beam. We could design an infinite number of such beams: it is a question of getting the cheapest, with sufficient bond strength.

Try one with a large percentage of steel: Say $r = 0{\cdot}010$. Assume $\frac{a}{h}$ will be $0{\cdot}10$. Then from the curves:

$$\frac{M}{M_n} = 1{\cdot}5$$

$$\therefore M_n = \frac{M}{1{\cdot}5} = \frac{30{,}000}{1{\cdot}5} = 20{,}000 \text{ in. lbs.}$$

$$M_n = \frac{cub}{2} \times a$$

$$= 300 \times 0{\cdot}36h \times 0{\cdot}88h$$

$$\therefore h^2 = \frac{20{,}000}{300 \times 0{\cdot}36 \times 0{\cdot}88} = 210{\cdot}4$$

$$h = 14{\cdot}505 \text{ in.}$$

$$\therefore A = 0{\cdot}145 \text{ sq. in. per inch section of beam.}$$

Then from the curve

$$\frac{u}{h} = 0{\cdot}3485,\quad \therefore u = 5{\cdot}055 \text{ in.}$$

$$= 0{\cdot}1h = 1{\cdot}45 \text{ in.}$$

Now check this by formula 4.

$$C = \frac{6M(h + a - 2u)}{ub(2u^2 - 4u(h + a) + 3(h^2 + a^2)}$$

$$= \frac{6 \times 30{,}000(14{\cdot}5 + 1{\cdot}45 - 10{\cdot}11)}{5{\cdot}055(51{\cdot}1 - 20{\cdot}22 \times 15{\cdot}95 + 3 \times 212{\cdot}5)},$$

$$= \frac{1{,}80{,}000 \times 5{\cdot}84}{5{\cdot}055(51{\cdot}1 - 322{\cdot}5 + 637{\cdot}5)},$$

$$= \frac{10{,}51{,}200}{5{\cdot}055 + 366{\cdot}1}$$

$$= 568{\cdot}02,$$

say, 568 lbs. per sq. in.

(See Table I(B), which shows that when $\frac{M}{M_n} = 1{\cdot}5$ C must be about 569 lbs. er sq. in.)

Now try a beam with small percentage of steel:

Say $r = 0{\cdot}007,\ \frac{a}{h} = 0{\cdot}010$

hen $\frac{M}{M_n} = 1{\cdot}055$

$$\therefore M_n = \frac{M}{1{\cdot}055} = \frac{30{,}000}{1{\cdot}055} = 28{,}436 \text{ in. lbs.}$$

then $28{,}436 = 300 \times 0{\cdot}36h \times 0{\cdot}88h$

$$h^2 = \frac{28{,}436}{300 \times 0{\cdot}36 \times 0{\cdot}88} = 299{\cdot}1$$

$$h = 17{\cdot}29 \text{ in.}$$

$$A = 0{\cdot}007 \times 17{\cdot}29 = 0{\cdot}121 \text{ sq. in.}$$

See which of these beams is cheaper, and if necessary try an intermediate one.

TABLE I(A).

$h = 10$ in., $a = 1{\cdot}0$ in., $b = 1$ in., $M = 9{,}504$ in. lbs.

u	f_t	f_c	c	A
3·6	9,414	3,824	352·99	0·1137
3·5	10,464	4,025	375·62	0·102083
3·4	11,620	4,226	399·053	0·091$\dot{4}$
3·3	12,894	4,426	423·39	0·0825
3·2	14,304	4,627	448·72	0·0742
3·1	15,864	4,828	475·17	0·06674
3·0	17,600	5,099	502·86	0·06
2·9	19,535	5,228	531·94	0·05391

$$c = \frac{6M(h + a - 2u)}{ub(2u^2 - 4u(h + a) - 3(h^2 + a^2))},\ f_t = 15c\frac{h - u}{u},\ f_c = 15c\frac{u - a}{u},$$

$$A = \frac{u^2}{30(h + a - 2u)}.$$

TABLE I(B).

u	$\frac{u}{h}$	f_t	c	A	r	M	$\frac{M}{M_n}$
3·6	0·36	16,000	599·94	0·1137	0·01137	16,153	1·6996
3·5	0·35	,,	574·32	0·102083	0·0102083	14,531	1,529
3·4	0·34	,,	549·46	0·091$\dot{4}$	0·0091$\dot{4}$	13,086	1·3769
3·3	0·33	,,	525·38	0·0825	0·00825	11,794	1·2409
3·2	0·32	,,	501·93	0·0742	0·00742	10,631	1·1186
3·1	0·31	,,	479·046	0·06674	0·006674	9,585	1·0086
3·0	0·30	,,	457·15	0·06	0·006	8,640	0·9091
2·9	0·29	,,	435·66	0·05391	0·005391	7,784	0·8190

TABLE 2(A).

$h = 10$ in., $a = 1{\cdot}25$ in., $b = 1$ in., $M = 9{,}504$ in. lbs.

u	f_t	f_c	c	A
3·6	10,146	3,726	380·48	0·106337
3·5	11,235	3,889	403·31	0·09608
3·4	12,437	4,053	427·12	0·08659
3·3	13,750	4,207	451·50	0·078065
3·2	15,205	4,361	477·06	0·070378
3·1	16,818	4,509	503·74	0·063432
3·0	18,609	4,652	531·69	0·057147
2·9	20,604	4,788	561·055	0·051437

TABLE 2(B).

u	$\frac{u}{h}$	f_t	A	c	r	M	$\frac{M}{M_n}$
3·6	0·36	16,000	0·106337	600·02	0·0106337	14,988	1·577
3·5	0·35	,,	0·09608	574·35	0·009608	13,535	1·4241
3·4	0·34	,,	0·08659	549·49	0·008659	12,227	1·2865
3·3	0·33	,,	0·078065	525·37	0·0078065	11,059	1·1636
3·2	0·32	,,	0·070378	502·01	0·0070378	10,001	1·0523
3·1	0·31	,,	0·063432	479·26	0·0063432	9,042	0·9514
3·0	0·30	,,	0·057147	457·15	0·0057147	8,172	0·8598
2·9	0·29	,,	0·051437	435·66	0·0051437	7,380	0·7765

TABLE 3(A).

$h = 10$ in., $a = 1\frac{1}{2}$ in., $b = 1$ in., $M = 9{,}504$ in. lbs.

u	f_t	f_c	c	A
3·6	10,872	3,567	407·69	0·100465
3·5	11,996	3,691	430·64	0·09074
3·4	13,231	3,809	454·41	0·081986
3·3	14,591	3,920	479·104	0·07408
3·2	16,091	4,023	504·82	0·06693
3·1	17,751	4,116	531·67	0·06044
3·0	19,593	4,199	559·81	0·05$\dot{4}$
2·9	21,645	4,267	589·38	0·04918

TABLE 3(B).

u	$\frac{u}{h}$	f_t	c	A	r	M	$\frac{M}{M_n}$
3·6	0·36	16,000	599·997	0·100465	0·0100465	13,987	1·4717
3·5	0·35	,,	574·39	0·09074	0·009074	12,676	1·3338
3·4	0·34	,,	549·52	0·081986	0·0081986	11,493	1·2093
3·3	0·33	,,	525·39	0·07408	0·007408	10,422	1·0960
3·2	0·32	,,	500·84	0·06693	0·006693	9,450	0·9943
3·1	0·31	,,	479·25	0·06044	0·006044	8,566	0·9014
3·0	0·30	,,	457·143	0·05$\dot{4}$	0·005$\dot{4}$	7,761	0·8160
2·9	0·29	,,	435·67	0·04918	0·004918	7,035	0·7392

TABLE 4(A).

$h = 10$ in., $a = 1{\cdot}75$ in., $b = 1$ in., $M = 9{,}504$ in. lbs.

u	f_t	f_c	c	A
3·6	11,584	3,349	434·41	0·09495
3·5	12,742	3,431	457·42	0·08597
3·4	14,013	3,503	481·26	0·077845
3·3	15,411	3,565	506·02	0·070485
3·2	16,951	3,615	531·81	0·0638
3·1	18,656	3,650	558·77	0·05772
3·0	20,546	3,669	587·02	0·05217
2·9	22,649	3,669	616·73	0·04712

TABLE 4(B).

u	$\frac{u}{h}$	f_t	c	A	r	M	$\frac{M}{M_n}$
3·6	0·36	16,000	600·12	0·09495	0·009495	13,127	1·3812
3·5	0·35	,,	574·38	0·08597	0·008597	11,934	1·2557
3·4	0·34	,,	548·35	0·077845	0·0077845	10,854	1·1418
3·3	0·33	,,	525·36	0·070485	0·0070485	9,868	1·0382
3·2	0·32	,,	501·98	0·0638	0·00638	9,064	0·9439
3·1	0·31	,,	479·22	0·05772	0·005772	8,051	0·85763
3·0	0·30	,,	457·14	0·05217	0·005217	7,441	0·77874
2·9	0·29	,,	435·68	0·04712	0·004712	6,714	0·7064

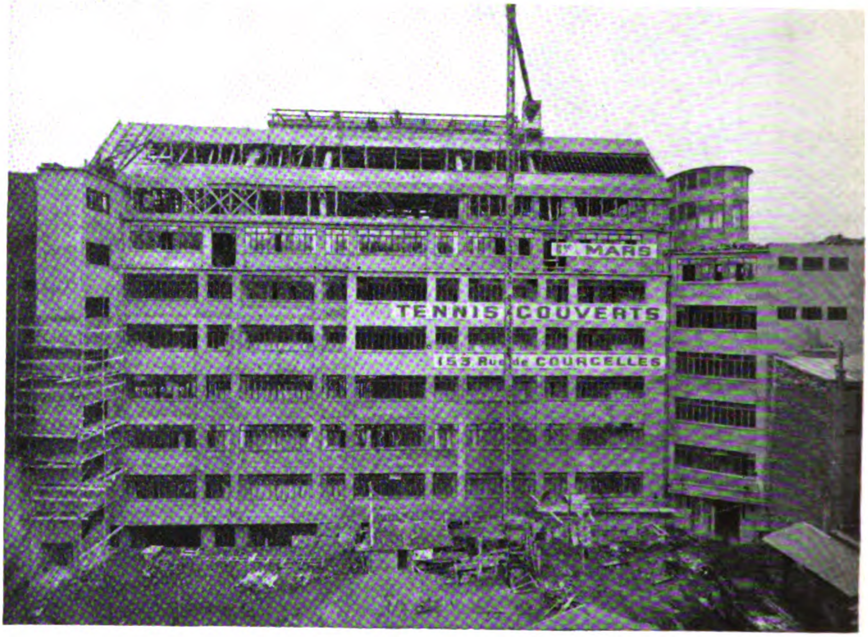
Technical Education.

THE syllabuses and arrangements for the Session 1927–1928 of the building and engineering schools are now being issued.

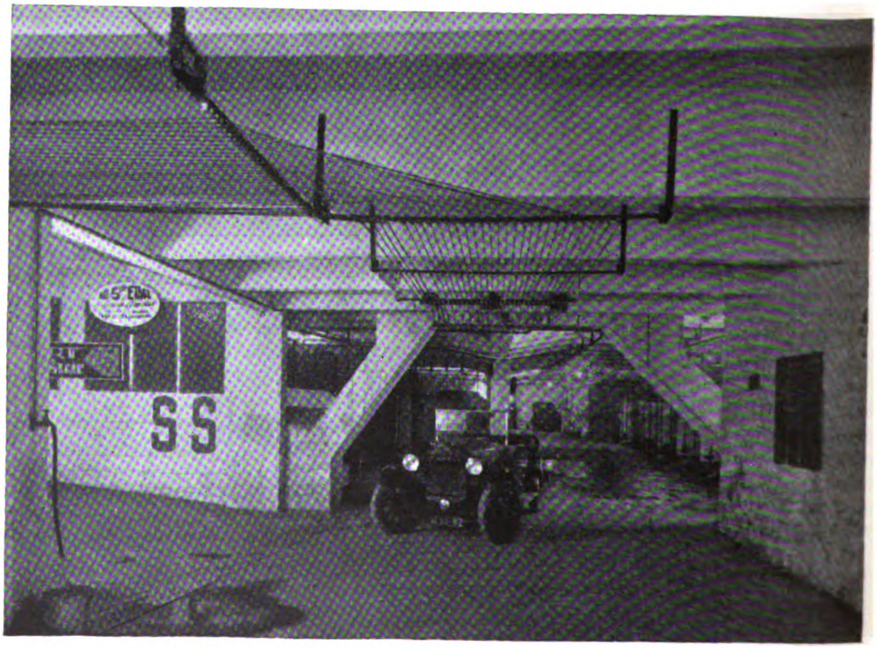
The City and Guilds of London Institute has published a volume of 464 pages, containing the general regulations and syllabuses for examinations (price 3*s.* 6*d.* net). The City and Guilds (Engineering) College, Exhibition Road, S.W.7, forms the engineering section of the Imperial College of Science and Technology. The courses of instruction cover a period of three years, commencing in October, and include civil engineering. The age of admission is over 16 years. The prospectus of the College may be had on application.

University College (*University of London*) *Faculty of Engineering* commences the new session in October. There are three-year courses, separate classes, and evening classes at low fees in all engineering subjects, including reinforced concrete. Students desiring to take degree courses must have passed the Matriculation Examination of the University, or have been exempted therefrom ; other students may be admitted without previous examination provided their previous education is such as to enable them to follow the work of the classes.

The University of Manchester and the Manchester Municipal College of Technology have issued prospectuses detailing the programme of the course on building construction (including reinforced concrete) at the University, and of the part-time classes in building at the College of Technology.



Exterior View.



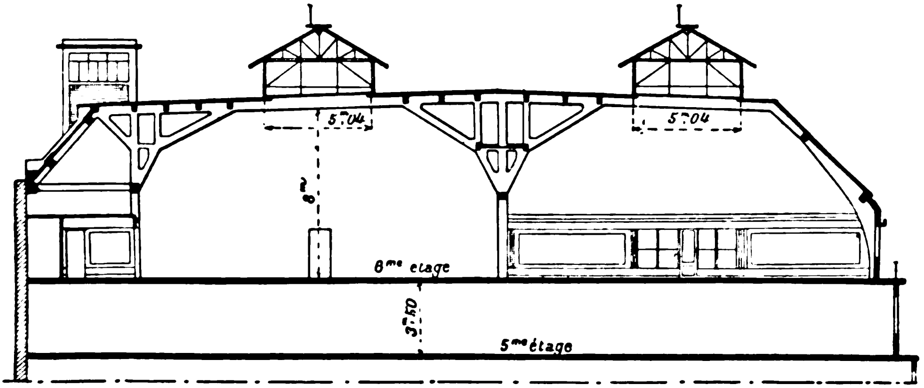
Interior of Basement.

Nine-Floor Reinforced Concrete Garage. (*See p.* 611.)

Nine-Floor Reinforced Concrete Garage.

In Paris there are no less than 200,000 motor-cars, and owing to the high value of sites in the middle of the city it is realised that only by building high garages can the cost of storing cars be kept within reasonable limits.

The Banville Garage, in the heart of a busy district, has recently been completed to hold six hundred cars on seven floors. The eighth floor is fitted up for the sale of motor accessories, and the ninth with tennis courts. The area of the building site is 36,000 sq. ft., and the story height 11 ft. Our illustrations, which are from *Le Génie Civil*, show the lay-out of this modern type of garage.



Cross Section at Roof.

The fundamental idea in designing the building was to have a separate enclosure for each car (in which washing, cleaning, and small repairs might be carried out) and an easy access from the street to any of the lock-up compartments. The design therefore involved questions of the size of compartments, the ratio of the number of each size to the total number, the spacing of the columns, the lay-out of water pipes, and the problem of ventilating the building.

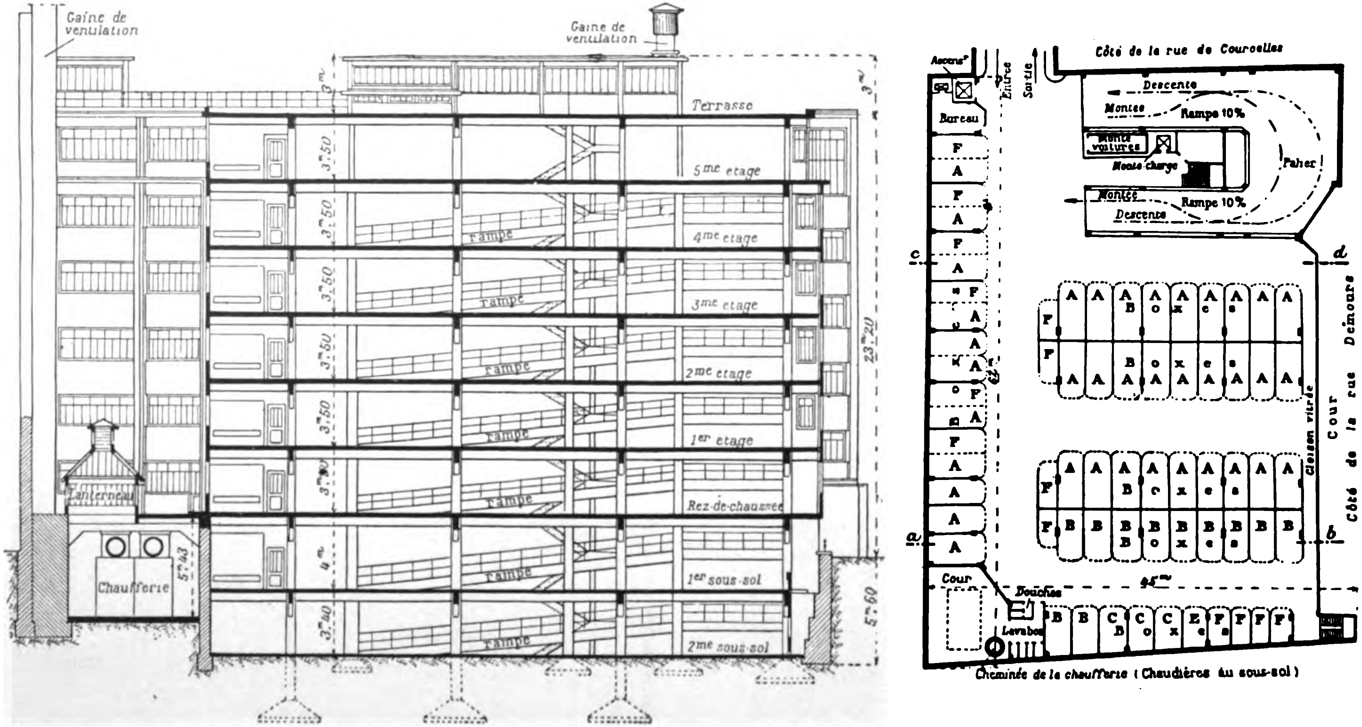
It was found that the size of cars is very far from being standardised, and that two 10-h.p. cars cannot always occupy compartments of equal size without a loss of space. It was decided to divide all cars into six classes and six classes of compartments were designed.

A still more difficult problem was to discover what proportion the number of compartments of any class should bear to the whole. Obviously it would vary from hour to hour. Finally the designers resolved to make the sides of the compartments movable, but even so the number of possible combinations is limited by the column spacings. Of course, the latter could be made larger but only at the expense of deep beams. A maximum span of 40-ft. was used.

Reinforced concrete was preferred to steel for three reasons: (1) Economy in first cost and maintenance; (2) safety in case of fire; and (3) because the floors are more easily made watertight. It will be realised how important watertightness is when it is stated that each day more than 22,000 gallons of water are passed over the floors. High-strength cement was employed, and the formwork was removed in from four to seven days, according to the part of the building, after pouring the concrete.

A plan and section are given on page 612.

The working stresses employed were 17,000 lbs. per sq. in. for steel, and 850 lbs. per sq. in. for concrete, which was mixed in the proportions of 594 lbs. of cement per cubic yard in place.—W. S. G.



Longitudinal Section and Ground Floor Plan of Reinforced Concrete Multi-Story Garage. (*See p.* 611.)

Book Reviews.

Fire Resistant Construction.

Building Research Special Report No. 8. Pp. 57 + vi. H.M. Stationery Office. Price 1s. 6d. net.

THE building industry is again indebted to the Building Research Board for the scientific treatment of a subject formerly in the region of rule-of-thumb. The well-known "red books" on fire-resistant construction had largely an empirical basis, but this report deals with the matter from theoretical foundations.

The first part of the report considers the usual building materials and discusses their resistance to the action of fire. Timber and steel require but brief space, and even natural rocks (such as granite, sandstones, and limestones) are found to be lacking in their powers of endurance against fire. Among artificial building materials, the clay products such as brick and terra-cotta are concluded to be "probably the best fire-resisters."

The greater part of the pamphlet is, however, devoted to the results of experiments for improving the fire-resistant qualities of cement and concrete, no doubt upon the basis that the latter is the most important of modern constructional materials. Commencing from the standpoint that the lime set free during setting of cement constitutes a weakness in connection with fire resistance, because it leads to contraction when heated and disintegration on subsequent wetting, the experiments were designed to discover a material that could be mixed with the cement and combine with the liberated lime. Suitable materials were found to be clinker from steam boilers, baked clay, and granulated slag. A mixture of either of these materials finely ground with Portland cement and a suitable fire-resisting aggregate produces a concrete which can be submitted to high temperatures without a disastrous reduction in strength, while on subsequent moistening and ageing of the fired specimens there is a tendency to regain strength.

It is pointed out that the report deals with small laboratory specimens which attain the test temperatures of 1000 deg. F. to 2000 deg. F. throughout their dimensions in a short time, and thus give extreme results compared with the heating effects of an actual fire upon the surface only of large structural members. Hence the successful laboratory results in the report can be taken as possessing a large factor of safety when applied to actual practice. The materials required for mixing with cement to improve its fire-resisting qualities are artificial imitations of the natural "pozzolana" or "trass," which are used in the Continental countries where they exist for incorporating in concrete used for sea water work. The pamphlet describes methods of estimating the pozzolanic value of burnt clay and other materials and also of estimating the amount of free lime in set cement; this part of the investigations constitutes a very valuable addition to the knowledge upon the subject of pozzolanas and their action.

The commercial application of the discoveries will depend upon the ability to rely upon cheap supplies of artificial pozzolanas of consistent quality, and also upon the widespread occurrence of concrete aggregates with fire-resisting qualities; it would be futile to use a fire-resistant cement in conjunction with a granite or limestone aggregate, and concrete construction is generally limited by the necessity of using local aggregates to avoid high transport costs.

The report is clearly written and well illustrated by graphs, but in a scientific report it would have been useful to include the tables of figures from which the graphs were drawn. It is satisfactory to learn that the investigations upon reinforced concrete construction and upon large-scale specimens are being continued.

"Management and Methods in Concrete Highway Construction." By J. L. Harrison.

London: McGraw-Hill Publishing Co., Ltd. Price 15s. net.

A BOOK collating all the available information on American practice in concrete road construction has been long overdue, and the gap is now admirably filled in this volume by the Highway Engineer of the United States Bureau of Standards. Besides giving concisely the results of experiment and experience that have hitherto been published in pamphlets, and in the form of papers read before technical societies or articles in the technical press, the author's own extensive knowledge of the subject is seen throughout the work and the benefit of his experience passed on.

American methods of concrete road

construction are now standardised to such an extent that the number of pages dealing with design and materials is relatively small. The greater part of the book deals with organisation on the job with a view to obtaining maximum efficiency and keeping down costs. Thus 15 pp. are devoted to a discussion on the best methods of stock piling, and another 15 pp. deal with the problem of hauling the mixed concrete from the mixer to the position where it is required; the advantages of various types of road lorries and the timing of each trip occupy 24 pp.

It appears that two things are now definitely agreed in the United States: the first is that the all-concrete road is the most suitable and cheapest for modern traffic; and the second the design of these roads for the different classes and volumes of traffic that come upon them. Attention is now being given to organisation and management, and these subjects are covered very thoroughly in this volume.

"Moderne Grundbautechnik." Part I, by I. Zeissl, 64 pp., 29 illustrations, 3 tables, Part II, by O. Stern, 56 pp., 11 illustrations, 1 table.
Berlin: Wilhelm Ernst & Sohn. Price: 2·70 mk. each, in paper.

"Belastung des Baugrundes." By Ö:N.I.G. (Austrian Industrial Standards Committee) 78 pp., 17 illustrations.
Vienna: Ö.N.I.G.

THESE three booklets all deal with foundation problems. The first two are in the main descriptions of the patented piling apparatus handled by the Stern Company in Vienna, and the third a collection of articles and other publications that have appeared from time to time in connection with the standardisation of test loads, test apparatus for determining the bearing value of the ground, classification of various soils, assumptions for load distribution below ground level, etc.

The scientific investigation of the properties of the soils generally met with on building sites has been carried to a very high degree of accuracy by the Austrian Committee, and forms interesting reading for engineers who specialise in foundation work and are desirous of obtaining the latest information on the subject.

The Stern method of pile driving is characterised by the employment of compressed air for forcing concrete into the cavity left when withdrawing a closed tube previously driven into the ground. The compressed air is also used for working the pile hammer, which operates in the bottom of the piling tube and acts directly on the massive pile shoe. The method shares the defect inherent to all *in situ* piling, namely, that the pile supporting the structure is not the pile that has been driven, and the carrying capacity of the substituted concrete pile bears no very definite relation to that of the pile driven and withdrawn. The Stern piling apparatus has many ingenious features but would appear to require skilled manipulation by highly-specialised labour or else very efficient and constant expert supervision. —R.N.S.

"Der Eisenbetonbau." By C. Kersten, 3rd volume: Practical Structural Examples. 217 pp., 253 illustrations.
Berlin: Wilhelm Ernst & Sohn. Price: Paper, 4·50 mk.; cloth, 5·40 mk.

THIS is the last of three volumes on reinforced concrete, and forms the practical conclusion of the two preceding textbook volumes. It contains a series of examples of actual calculations for various members of reinforced concrete structures met with in ordinary practice, such as slabs, beams, cantilevers, lintels, hollow floors, stairs, walls, foundations, etc. The question of continuous beams is treated at length, and a number of useful tables for their computation are given at the end of the book. The illustrations, in their clearness and excellence of execution, form no exception from the high standard to which the Ernst textbooks are kept, and not only are of great assistance in explaining the matter, but are almost sufficient in themselves to enable a reader without knowledge of German to follow the course of calculations.—R.N.S.

"Healing" of Cracks in Concrete.

SOME interesting evidence on the "healing" of cracks in concrete was given before a recent meeting of the American Concrete Institute by Professor Duff Abrams and Mr. J. J. Earley.

Professor Abrams said the question was not a new one, as he had observed in a number of cases that concrete which has been ruptured at an early period would, if left exposed to the elements, gradually heal up and become even stronger than it was originally. The most striking evidence of that kind was some tests made at the Lewis Institute. Eight years previously they had tested a good many concrete cylinders to failure at the end of 28 days. These cylinders were placed in the yard, and some years later it was decided to put them in the machine again and re-load them, and they not only took as much load as they had originally taken, but gave values from 167 to 379 per cent. of the original 28-day strength. His opinion was that the small fissures in the concrete which were opened up at the time of the original test were actually welded together by the subsequent depositing of the soluble materials from the cement and aggregate. It was actually a healing process, and the concrete gained in strength much as it would if it had not been subjected to its original load.

A few years earlier still he had occasion to make a test on a reinforced concrete highway bridge in Illinois built by the State Highway Department for testing purposes. The bridge had been loaded when three or four months old and some very decided cracks had occurred in the end of the girders; both ends of both girders were cracked on both sides, and in many instances showed a number of the characteristic diagonal cracks seen in girders of that kind that were overloaded. A number of props were put under the bridge in case it failed, but later up to thirteen times the original load was put on the bridge. Some of the cracks never opened, but new cracks opened alongside of them, showing that the original cracks had entirely healed and were as strong or stronger than the original concrete. Those two illustrations, he thought, bore evidence of the fact that this healing feature was a real factor and might be of interest in other connections.

Mr. J. J. Earley mentioned that in 1917 he made a very long balustrade. The surface of the concrete was treated before it was thoroughly set by brushing it with steel wire brushes until the aggregate was exposed uniformly over the surface. It was necessary to apply this treatment to all four sides of the hand rail because the bottom of it could be seen between the balusters. Therefore, it was necessary to turn the rail over before the cement had hardened enough to resist the action of the wire brush. Several of the rails were broken in the turning and were discarded, and as an experiment a broken rail was bedded down true in sand. The fracture was covered with sand, and twice a day saturated with boiling water until the fracture was seen to be thoroughly knit together and almost invisible. The section of this rail was 7 in. by 14 in. The concrete was then allowed to dry and, although it was 14 ft. long, it was handled and set in the usual way, and has remained sound.

After this experiment established the fact that broken concrete would heal, he had, whenever the occasion had arisen, deliberately used the process with uniform success. However, he had always applied the process to new concrete; that is, to concrete from which the original mixing water had not evaporated. Consequently he did not know to what degree control might be exercised over the healing of old concrete which had thoroughly dried, but he felt sure that the power to heal remained in old concrete.

Mr. S. C. Hollister referred to a six-span structure consisting of arches of 80 ft. and span rise of about 14 ft. In the construction of one of the arches the shuttering slipped down about an inch, with the result that the concrete immediately over the pier, which was 4 ft. deep in that particular place, was cracked through to the full width of the bridge immediately over the face of the pier. The crack opened about ⅛ in. on the top face. After consideration he decided to see if the healing process would be efficacious, and immediately put on sand to the depth of about a foot; dikes were cut at both ends of the pier, and the drains in the low portion where the two barrels come together were filled so that they could not release any moisture. The sand was covered with bagging, and

A Reinforced Concrete Shop Front in Paris.

the bagging and the sand kept continually wet for four days. Since the crack had opened so much it was not possible for one cement surface to jump over to the other cement surface, and since the crack was not incipient, as has been described in the other cases of healing, it was necessary to introduce something to serve as a filler, and the sand, with the excess water carrying it down slowly as far as it would go, served that purpose. Examination four days later showed that only about one-third of the crack was visible. A week following that, examination disclosed that the entire crack had disappeared. It is not now possible to detect the position of that crack. From that time the concreting operations proceeded as before, as though nothing had happened, and the centering was struck from the arch 28 days from the time the crack was discovered.

Conference on Engineering Materials at Berlin.

Preparations for a conference on Engineering Materials, which is to take place at Berlin from October 22 till November 13 this year, have already far advanced. The programme of papers contains about 200 lectures. Three groups of engineering materials will be dealt with, namely: iron and steel, non-ferrous metals, and electrical insulation materials. More than 200 testing machines will be shown in operation. Detailed particulars may be obtained from the Geschäftsstelle der Werkstofftagung, Berlin, N.W.7.

Materials for Concrete Road Construction.

By R. A. B. SMITH, A.M.Inst.C.E., A.C.G.I.

THANKS to the hydrating properties of cement it is possible to mix it with water and bind together inert materials in such a way that they can be placed in position in a plastic condition, made to conform to the required shape, and then be left to harden and become permanent. By this use of cement it is actually possible to get better wearing qualities and better weathering properties from materials that in themselves are incapable of resisting either wear or weather conditions for any prolonged period. It is usual to carry out certain tests, which will be described later, to ascertain the suitability of the aggregate and the correct proportions.

Having decided on these it is advisable to take tests of the mix from time to time. Test cubes or cylinders are broken at 7 and 28 days. It is often too long to wait 28 days in order to see that the mix is right, but it is reasonably accurate to calculate the result at 28 days from the 7-day tests, using the formula $S_{28} = S_7 + 25\sqrt{S_7}$.

Strength.—As concrete is more severely tested in roadwork than in any other form of construction it must be treated sensibly. To ignore certain definite rulings courts disaster. By carrying out very simple tests, expense may be saved not only immediately but later in the cost of maintenance. The strength of concrete depends on properly mixing together the correct proportions of each of the constituents, and the quantity of water used must be just as accurately gauged as the quantity of cement or aggregate.

To obtain the highest strength from a test cube, only just sufficient water must be used as will enable all the materials to mix thoroughly together. This absolute minimum is not advisable in roadwork, as not only is it lacking in plasticity but with such a mix it would be impossible to obtain a proper close-knit surface. A very small extra percentage of water above the minimum will accomplish this, and once this is decided a slump test will give the standard.

The slump test is a method of measuring the consistency of concrete. The only apparatus required is a sheet-metal truncated-cone-shape mould, 12 in. high, 8 in. in diameter at the base and 4 in. in diameter at the top, provided with handles at the sides, and a ⅝-in. diameter pointed metal rod about 1 ft. long. The mould is filled with concrete in layers of 4 in. at a time, each layer being punned exactly thirty times with the rod. After the third (and last) layer has been punned, the mould is lifted off and the slump measured. The slump is the distance the cone of concrete settles after the mould is removed. A concrete of such a consistency that the slump is from ½-in. to 1-in. (that is, the mass settles down to 11½ in. or 11 in. when the mould is removed) will contain only a little more water than is necessary for maximum strength.

An increase of 10 per cent. in the water content will increase the slump to 3 in. or 4 in., while an increase to 25 per cent. of water will increase

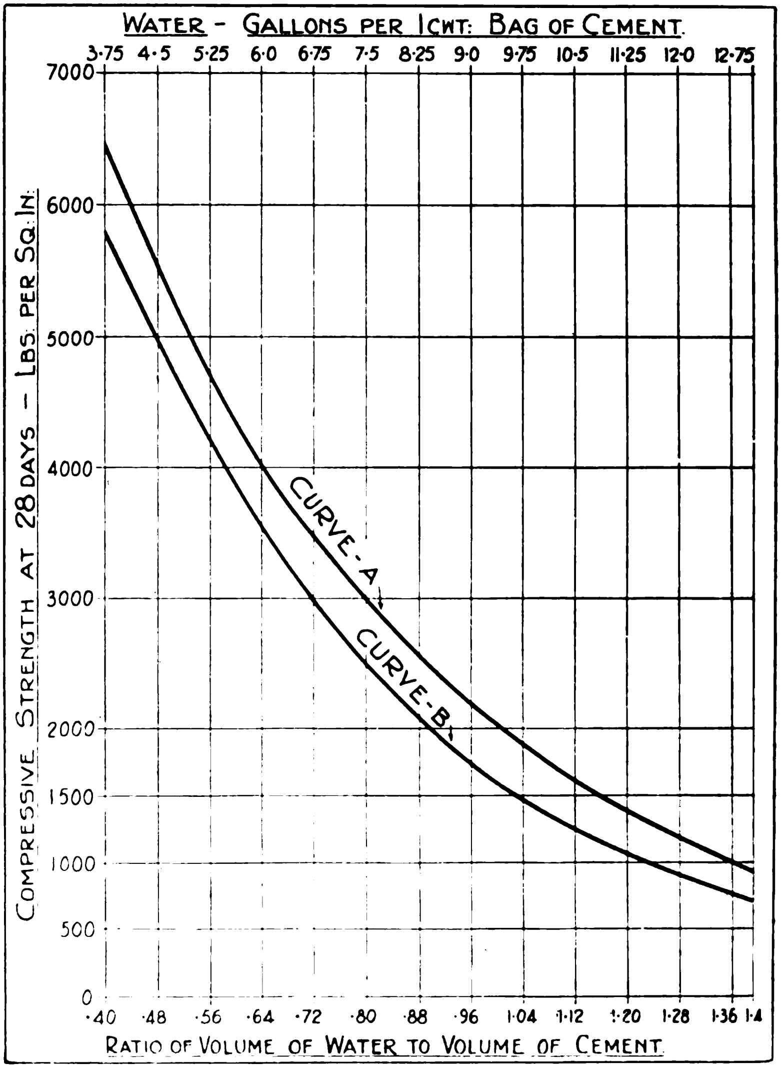


Fig. 1.—Effect of Water Content on Strength of Concrete.

the slump to 6 in. or 7 in. The method of making the slump test is shown in *Fig.* 2.

Assuming that 6 gallons of water are required to a sack of cement to obtain sufficient plasticity a slump test is then made and the slump is found to be, say, 1½ in. This should be set as the standard, and subsequently, however wet or dry the aggregate may be, it will only be necessary to adjust the water supply to obtain the pre-determined slump, or something very near to it.

It is more dangerous to make the concrete too dry than to make it too wet, and it is this very fact that leads to a far too generous use of water. The diagram (*Fig.* 1) gives a fair idea of the effect of the quantity of water used on the strength of concrete obtained. Curve A shows the results obtained by breaking cubes made in the laboratory; Curve B shows the results which will probably be obtained when the cubes are made on the job with the same aggregate and cement.

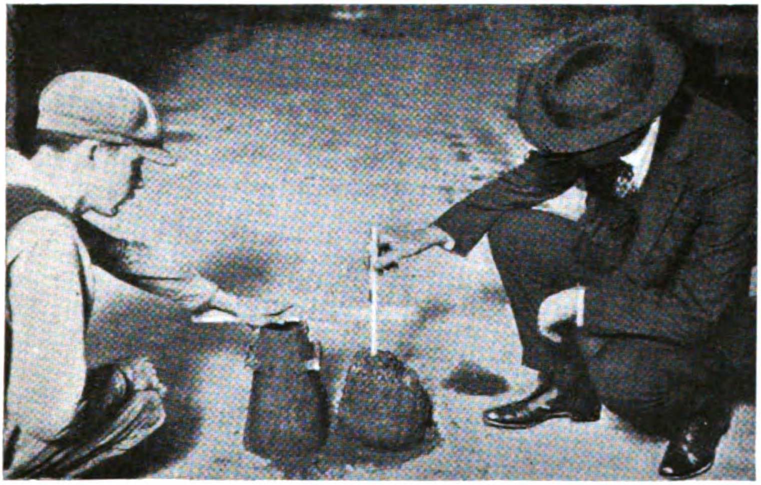


Fig. 2.—Method of making Slump Test.

For concrete roads, one should endeavour to obtain a strength of 3,000 lbs. at 28 days from the laboratory tests. The quantity of water required, on reference to the curve, is 7·5 gallons to a sack of cement, and the cubes made on the jobs may be expected to break at about 2,500 lbs. When the laboratory tests show a result of over 2,000 lbs. the mix may still be considered acceptable, but if they go lower than this it would be advisable to see if the extra strength can be obtained with rapid-hardening Portland cement if no better aggregate is available.

Water.—It may be accepted that all water which is fit for drinking is also fit for use in mixing concrete, but fortunately this is not the limit and no water should be discarded as unfit for use until a test has been made. Waters polluted by certain definite industries, such as tanneries, are likely to be dangerous, whilst in other cases the dilution of the pollution is sufficient to enable one to use the water without fear of evil consequences.

The use of sea water is often condemned for reinforced concrete, and yet there seems to be some modification necessary as far as Great Britain is concerned.

In 1924, Mr. Persey, Engineer to the Barrow-in-Furness Corporation, constructed 3½ miles of concrete road along the sea front, to which reference has already been made. He used sea water in mixing the concrete for the bottom course and used high-tensile steel reinforcement. In the top course he used fresh water, as it was not desired to run any risk of the wearing properties of the surface being reduced. So far there is no evidence of any action between the salt and the reinforcement.

It would be rash to state that because of this instance sea water can be safely used, but at the same time the author is of the opinion that tests will eventually show that so far as Great Britain is concerned sea water can be safely used, even though the concrete is reinforced, provided that the concrete is sufficiently dense and is being used for road purposes.

For unreinforced concrete, sea water is commonly used, and it has been shown that less than 0·1 lb. of cement is required to counteract the effects of the salt in a gallon of this water. At Fleetwood, the Engineer has for some years made all the various products necessary to a municipality in his own yard, using sea sand, and the percentage of sea salts present has not proved in any way detrimental.

The use of common salt for the purpose of lowering the freezing point has been shown by an exhaustive research by Professor Duff Abrams to be dangerous. It requires not less than 5 per cent. of salt to reduce the freezing point of water 6 degs. F. and the reduction of the strength of the concrete is about 30 per cent. In sea water the percentage of salts, chiefly sodium chloride, does not exceed 3 per cent.

Perhaps the most interesting conclusion at which Professor Abrams arrived was that there is " a marked reduction in strength of concrete with increase in quantity of mixing water for both fresh and impure waters. Increasing the mixing water by 1 per cent. reduced the strength of concrete about the same amount as if the cement were reduced 1 per cent. A comparatively slight increase in the quantity of mixing water produced a greater reduction in concrete strength than that produced by the use of the most polluted mixing water that is ordinarily encountered." Peat bog water is not necessarily unsuitable but should be tested for organic matter.

There has been a good deal of discussion on the subject of what is called the water-cement ratio. The net result is that it is practicably possible to specify the strength required in the concrete at 7 or 28 days and leave the actual ratios to the contractor so long as he supplies the concrete to the desired strength.

Let us assume that a strength of 3,500 lbs. at 28 days has been demanded. To obtain this on the weakest mix of concrete the contractor requires, say, 6 gallons of water. However, he finds this mix is not plastic enough for speed in placing, perhaps owing to the presence in the forms of complicated reinforcement. He must, therefore, make it wetter. He can, under the specification, make it wetter, but he has still to supply the required strength and keep within the limits of plasticity and workability. To do this he must put more cement into the wetter mix. There is a limit to the wetness possible, as the mix becomes unworkable.

Tests have shown that if the contractor uses a wet concrete to get workability he will actually have to put in enough cement to bring him back to the same ratio of cement to water as with a drier mix. Obviously this system simplifies matters between the engineer and the contractor. The latter having submitted his materials and shown they give the required strength when mixed in the proportion of, say, 1 : 2 : 4 and the addition of 6 gallons of water, it is easy to agree beforehand with the engineer the additions of cement for the various consistencies necessary for the job in order to keep the water-cement ratio constant.

For the contractor the method is satisfactory; he can speed up his work with wetter mixes if he thinks them advantageous, or he can use an extra good cement and make it go farther than a cement which just passes the specification, thus reducing his transport and handling costs whilst satisfying the engineer.

Sand.—So long as the sand is clean and reasonably free from argillaceous matter it should be suitable for concrete work, a further consideration being that it should not contain an excess of fine material.

For the purposes of a standard it is reasonable to demand that not more than 20 per cent. should pass the 50-mesh sieve. Sands which are deficient in coarse grains may still be used in concrete but may require a higher proportion of cement.

The whole object of the sand and cement is to bind the coarse material together. As the coarse material is to take the wear, it is essential that this mortar shall be intimately mixed in order to gain the desired result. It is considered, therefore, that when material is hand mixed these two ingredients, the sand and cement, should be first mixed together dry before the coarse aggregate is added—by this means it is possible to get the sand particles well coated with cement. When the sand is wet this is not easy to accomplish, as there is a tendency to " ball " when mixing in the normal way. Yet even though the " balling " takes place, the cement must be better distributed, and on the addition of the coarse aggregate the balls will be sufficiently broken up to complete the process.

The most general test necessary for impurities in sand is the tannic acid, or colorimetric test. The presence of 1 per cent. of tannic acid (organic matter) in sand which is to be used for concrete reduces its strength by over 25 per cent. and the increase in this percentage might even result in the complete failure of the concrete. The following describes an easy test for ascertaining the presence of this acid :—

Obtain a 12-oz. prescription bottle and a little 3 per cent. solution of caustic soda. Put in about 4½ ozs. of sand, fill up to the 7-oz. mark, shake with the solution of caustic soda, and let it stand. At the end of 24 hours observe the liquid on top. If the liquid is clear or light straw coloured the sand is passable, but if it is brown, and especially dark brown, the sand should be rejected, or, if no other is available, washed thoroughly until it passes the test.

It is also of importance, especially in Ireland, to be assured that no sulphur is present, and to ascertain this a very simple field test can be applied :—

Fill a test tube about one quarter full with the sample. Add dilute hydrochloric acid and warm over a flame, at the same time holding a piece of moistened lead acetate paper over the mouth of the test tube. If the paper turns a metallic brown in colour, sulphur is present. A distinct smell of hydrogen sulphide will most likely be noticeable. If sulphur is present the material must be regarded with suspicion and a proper laboratory test undertaken.

It is easy to lay down a definite quantity of sand in the mix. Thus in a 1 : 2 : 4 mix we are in the habit of taking each by volume, but there is a very considerably different proportion of sand if it is supplied dry from when it is supplied wet. Loose sand may bulk when damp to as much as 25 per cent. more than the volume of the same sand loose and dry, whilst if thoroughly wet it will hardly alter in volume. The specification should state the proportions required when the sand is loose and dry, as the reduction of sand within the limits possible due to damp will not be sufficiently detrimental to the ultimate strength : otherwise the clerk of works must be given the power to increase the proportion of sand by volume up to 25 per cent.

It is much preferable to vary the proportion of sand in the mix than to vary the proportion of water, and it will be found that if the contractor is not allowed some latitude with the sand he will most probably vary the water content according to the conditions in order to bring up a good close-knit surface.

Let us assume that the correct mix as determined in the laboratory with dry materials is 1 : 1½ : 3, and that the slump given with this mix and its correct percentage of water as required on the job is 3 in. How does the clerk of works settle as to what this means with wet aggregates on the job ?

He should be given the weight of 1 cu. ft. of dry loose sand—let it be, say, 90 lbs. He takes a cubic foot of the wet sand, dries it out on a pan, weighs it and finds it weighs 112 lbs. Then he will require

$$\frac{112}{90} = 1{\cdot}25 \text{ cu. ft. of wet sand,}$$

to keep his proportions correct.

The same method can be adopted to check the coarse aggregate.

The alternative method is to keep all the sand thoroughly wet, so that it has about the same bulk as dry loose sand.

(*To be continued.*)

Questions and Answers relating to Reinforced Concrete.

Readers are cordially invited to send in questions relating to concrete. These questions will be replied to by an expert, and, as far as possible, answered at once direct and subsequently published where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—Ed.

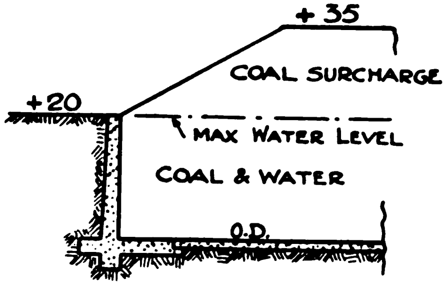
Design of Coal Store.

Question.—I am engaged upon designs for a coal store at an electrical generating station, and would be glad to have your opinion on certain queries which have arisen in connection therewith.

The conditions are as follows :—

Overall length, approximately 500 ft.
Overall width, approximately 150 ft.
Height of retaining walls, 20 ft.
Ground level outside store, +20 O.D.
Bottom level inside store, O.D.

The store is to contain coal, finely broken as customary for use in automatic stokers, and water (to prevent spontaneous combustion of coal) to a maximum height of +20 O.D., the coal being surcharged 15 ft. above this level—see sketch. The walls of the store retain earth on the outer side and coal + water on the inner side.



The queries are :—

(1) Has coal in water any harmful effect on concrete, or is it likely to set up corrosion in the steel reinforcement through fine cracks in the concrete ? Is 1½ in. cover to main reinforcement sufficient, or is it advisable to provide additional cover, and, if so, how much would you suggest ?

(2) Can you give me any data, based on practical experience, for the weight and angle of internal friction of coal in water, assuming the Rankine formula for the calculation of horizontal pressures.

(3) Assuming the use of the Rankine formula, what method would you use, or what assumptions would you make, to obtain the pressure on the wall in this case, where you have coal + water + dry coal surcharge. The earth pressure on outer side is, of course, simple.

(4) Is a simple concrete slab, reinforced with mesh fabric, without beams, suitable for the bottom of the store ? Having in view the large area and heavy loading, and the fact that watertightness is desirable, would it not be better to provide stiffening beams to this slab ? What thickness would you recommend for this slab ? S. H. H

London.

Answer.—(1) We do not think coal in water has any harmful effect on concrete, but it would of course depend on the coal ; if this were very high in sulphur it is possible that the sulphur might have a deleterious effect. In that case a rendering of the walls with aluminous cement would probably be the best protective measure. A cover of 1½-in. of concrete additional to such rendering would probably be quite sufficient, assuming that the concrete is of first-class quality and really dense and watertight.

(2) An angle of slope of coal in water might, we think, be taken at 35 deg.

(3) We think our correspondent could use the angle of 35 deg. throughout for the coal, whether it is wet or dry, and the formula is then of course a simple one. The difference between this and using test figures for the upper and lower layers would not in our opinion be sufficient to justify the complication involved.

(4) It depends entirely on the substrata. If the soil is quite firm and not liable to settle unequally, beams are probably unnecessary. In any case if the slab is a large one it should be divided up into sections small enough not to crack owing to shrinkage, these sections being connected by watertight expansion joints. We should prefer rod reinforcement to mesh fabric as reinforcement. Probably a slab 8-in. thick reinforced top and bottom is the minimum on which one can try.—O. F.

Bridges.

QUESTION.—I should be very much obliged if you could find room in your valuable columns for answers to the following :

In designing reinforced concrete flat bridges, the working stress of which has been taken as based on the strength of concrete at 28 days, which of the two methods is preferable ?

(1) At periods of about 5 days interval commencing 7 days after pouring the concrete, the wedges to struts under the deck are gradually eased, or

(2) That no easing of the deck take place until 24 to 28 days, when the whole structure is then gradually eased of its load by carefully withdrawing the wedges.

In the first case it would appear that the whole dead load is put on the bridge at the end of 7 days, but of course its full deflection is not permitted.

In the second case no stress whatsoever is placed on the concrete until 24 to 28 days. " REGULAR READER."

ANSWER.—In the case of slab bridges spanning from support to support without beams the second alternative should be adopted. The striking of formwork is a matter for decision on the site after inspection of the concrete, and depends to a considerable extent on weather conditions. With comparatively small spans and favourable conditions the period may be reduced to 14 days, or it may be still further reduced to one or two days by using aluminous cements.

The first method described in the question avails nothing and is practically equivalent to striking at 7 days, which may often be too early ; certainly part, and most probably all, the dead load would have to be carried by 7-day concrete.

The live load, of course, must not be allowed to come on the slab until at least 4 weeks have elapsed after pouring. —L. T.

All-Concrete Road at Truro.

[This all-concrete road has just been completed under the direction of Mr. F. A. Barnes, A.M.Inst.C.E., the City Engineer and Surveyor. It is 7 in. thick, reinforced with B.R.C. fabric.]

Joints in Concrete.

QUESTION.—Kindly inform me whether there is any method of making a joint in concrete that will form the separate masses into one monolithic block. I have recently tried the following experiments, which failed.

I filled two frames 6 in. by 9 in. by 5 in. to within ¾-in. from the surface with concrete, and allowed them to set for three days. On the third day I cleaned the surface of one by scraping it, and the other by washing it with commercial hydrochloric acid, being careful to wash off all traces of the acid with clean water. I then filled the frames to the top with a 1 : 1 mixture of cement and sand, tamping slightly and trowelling to an even surface. The samples were kept in a damp place and watered from time to time.

After ten days I tried the rendered surfaces with a hammer; hair cracks could be noticed at the corners before applying the hammer. The rattling sound of gentle knocks disclosed the existence of the joint. Subsequently by giving four or five hard knocks I cleared the rendering clean of the original surface in both samples, with no sensible difference. Before applying the rendering I washed the surfaces with clean cement applied with a new brush.

These results make me think that a perfect joint is not possible, but that the bond can only be obtained by artificial means, such as picking the surface, or using steel. Am I right?

L. GATE.

Malta.

ANSWER.—The experiments quoted are, in our opinion, not very conclusive, because only ¾-in. was added, and this would naturally shrink rather rapidly owing to loss of water by evaporation. Had a substantial mass of concrete been placed instead of a ¾-in. rendering probably a much better connection would have been obtained. The joint will, of course, depend very much on the efficiency of the rough surface, and we are not quite clear whether the scraping left a really rough surface with deep indentations. Had the rendering been kept wet for two or three weeks by being covered with wet sawdust or something equivalent, a much better result would probably be obtained. As our correspondent suggests, steel projecting from the first block into the second would add considerably to the strength of the connection.—O. F.

Tanks for Breweries.

QUESTION.—We have an inquiry for concrete tanks for brewery work. These tanks must be guaranteed to withstand fruit acids, and we are looking for a suitable lining. Can you suggest a suitable material for this purpose?

We understand that the temperature of the acids when being poured into the tanks is just under boiling point.—G. G.

ANSWER.—Providing concrete tanks are properly made, they should not need special lining in order satisfactorily to contain fruit acids. Probably the nearest approach to such tanks in existence is a series of tanks built at Kingston for the storage and fermentation of wine.

Some of these tanks were built fourteen years ago, and when the question of extending these storage tanks arose in 1925 the Company were so pleased with the service the twelve tanks built twelve years previously had given that they decided to erect the new tanks in concrete. These tanks each contain 14,000 gallons of wine. The latest ones to be erected were made of rapid-hardening Portland cement, and the inner faces rendered.

Full descriptions of these tanks were given in *Concrete and Constructional Engineering* for March, 1923, and September, 1925.

Effect of Sulphur Impregnation on Strength of Concrete.

THE following notes on the effect of sulphur impregnation of concrete are taken from a recent number of "Engineering News-Record," to which full acknowledgment is due :—

Tests extending over a number of years, and observations of some pre-cast concrete in place have shown that concrete may be impregnated with sulphur with an increase in strength and decrease in absorption. This fact, not too well known to engineers, may have application to concrete uses not heretofore tried.

Commercial flour sulphur, or sulphur in any other form, added to the mix has little or no effect on the strength even though this contained sulphur is subsequently melted. In carrying out the sulphur treatment the pre-cast concrete products, preferably well cured, are immersed in a bath of molten sulphur until the requisite degree of absorption has resulted. The treatment is applicable to all types of concrete and cement mortars, including aluminous cement and with any aggregate chemically inert toward sulphur. With the exception of cinder concrete products, these various concretes and cement mortars sink in molten sulphur.

The usual working temperature of a sulphur bath for the impregnation of concrete is 130 to 150 deg. C., although under certain conditions it may be advisable to employ higher temperatures of 160 or 180 deg. C.

The rate of absorption of molten sulphur by concrete is dependent upon a number of factors, moisture content probably being the dominant one. The first action which takes place when a piece of concrete at room temperature is lowered into a bath of sulphur is solidification and freezing of a layer of sulphur on the surface of the concrete. This soon fuses, however, and the temperature of the concrete gradually increases with evolution of steam and ebullition of the bath as the bubbles of steam pass through it. The driving off of the contained moisture has a tendency to retard the entry of the molten sulphur and to reduce the temperature of the concrete. It is therefore very desirable to utilise concrete containing a minimum quantity of moisture.

The physical condition of concrete also affects the rate of absorption. This is especially true of concrete products which have a more or less impervious skin of neat cement on the surface, such, for example, as occurs in concrete pipe made by rotary machines. The usual mixes of concrete such as are employed for the

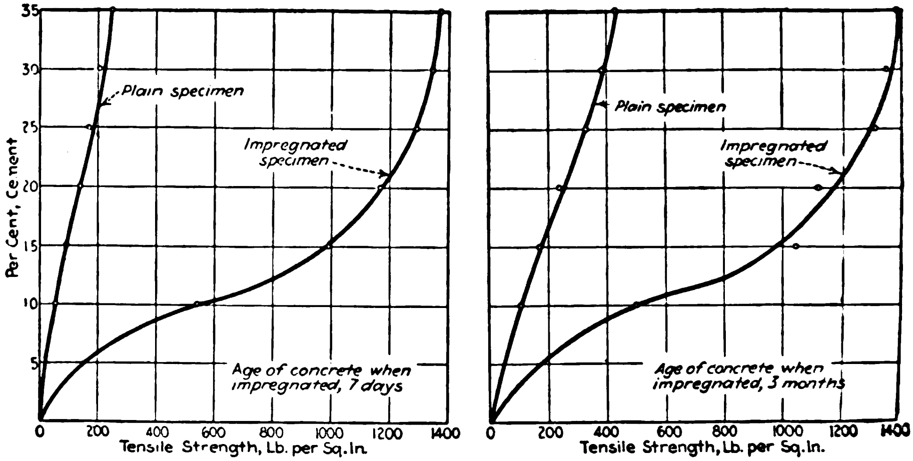


Fig. 1.

making of tanks and electrolytic cells if fairly dry may be impregnated at least for a distance of 2 in. in eight hours, or at the rate of ¼ in. per hour, but in many cases a much higher rate of absorption may be induced.

It is also sometimes helpful to immerse the concrete in a bath of 160 to 170 deg. C., and after two or three hours reduce the heat and temperature to 125 to 130 deg. C. This procedure is often efficacious where the concrete is of dense structure and with a pronounced moisture content. The use of vacuum or pressure, or both, in conjunction with this process of treating concrete with molten sulphur greatly assists and speeds up the treatment. It is not a difficult matter to adapt the present creosoting cylinders for use with sulphur, and in fact, this is now being done on a semi-commercial scale by one of the large railway companies for the purpose of treating fifty concrete ties with sulphur.

Impregnating Portland cement concrete and cement mortars with molten sulphur increases their tensile and compressive strengths. Standard tensile briquets of cement mortar which ordinarily break at about 150 lbs. per sq. in. are increased in strength to over 1,000 lbs.; in many instances sulphur-treated briquets have not failed below 1,700 lb., and a few have withstood a pull of 2,000 lb. per sq. in. The increase in tensile strength is shown graphically in *Fig.* 1, developed in co-operation with the Division of Construction and Tests of the North Carolina State Highway Commission.

In addition to the increase in tensile strength there is far less variation in the strength of the treated specimens than in the untreated. In other words, the plain specimens at an age of seven days, although not nearly as strong as those cured for three months, compare very favourably after treatment, and it therefore appears that sulphur impregnation brings about a marked increase in strength regardless of the age of the concrete at time of treatment.

Under compression, sulphur-treated concrete shows an increase in strength over the untreated similar to that indicated in the case of tensile tests. For example, a 1 : 5 mix of aluminous cement mortar when treated with sulphur showed an average strength of 14,000 lbs. per sq. in. under compression. Another series of tests of a similar mix of Portland cement under compression failed at 1,665 lbs. per sq. in. before treatment and 8,600 lbs. after being impregnated with sulphur. Standard 3 in. by 6 in. concrete cylinders impregnated with sulphur required 57,100 lbs., or 8,078 lbs. per sq. in., to bring about failure. Another series of treated cylinders showed a minimum strength under compression of 7,528 lbs. per sq. in. and a maximum of 9,641 lbs., with an average of 8,355 lbs. These cylinders are of standard concrete highway mix as used by the State Highway Commission of North Carolina.

The great increase in strength imparted to concrete by impregnating with sulphur may possibly be explained by the fact that sulphur contracts when solidifying and the crystalline forces tend to bind the entire mass together. The phenomenon is the opposite of what takes place when water freezes. The freezing of water-saturated concrete has a tendency to disintegrate the structure due to expansion, whereas when sulphur passes from the liquid phase to the solid there is marked contraction resulting in a consolidation and binding effect. In the case of concrete there may also be some chemical action, such as the formation of small quantities of iron sulphide or other sulphur compounds.

Sulphur is not nearly so inflammable as is popularly supposed. In the case of sulphur-impregnated concrete the fire hazard is very slight. This treated concrete will not support combustion, and cannot be ignited by ordinary flame. It is not as fireproof as untreated concrete, and when exposed to a degree of heat above the melting point of sulphur the contained sulphur melts and vapours are driven off. This will not destroy the concrete structure itself and the resulting mass would be in much the same state as when removed from the impregnating bath, the molten sulphur being held within the concrete by capillarity.

Although the cost of treating concrete with sulphur has not been worked out on a commercial basis, it is at least comparable with the cost of creosoting timber in standard treating cylinders, and may be somewhat lower.

Sulphur impregnated concrete has many commercial possibilities especially in the electrolytic field. It has been used for treating large electrolytic cells which have been in actual operation for nearly a year under the action of a mixture of hot ferrous and ferric chloride solution at the plant of the Niagara Electrolytic Iron Co. These cells are 14 ft. long by about 2½ ft. sq. in cross-section, and weigh approximately 4,000 lbs. with walls 3 in. thick. They were completely immersed in a bath of molten sulphur carried in a vat temporarily set up for the purpose, and remained in this bath for eight hours. The sulphur apparently penetrated all surfaces uniformly for at least an inch in depth, and it is reported that they are performing satisfactorily and withstand the very corrosive action of the electrolyte, which is a mixture of hot ferrous and ferric chloride solution. These cells are reinforced, and there appears to be no reason why reinforced concrete can not be treated satisfactorily with sulphur since it is assumed that in many cases the sulphur treatment will actually protect the reinforcement from corrosion on account of the very low absorption of the treated concrete.

Generally speaking, water absorption is reduced to less than 2 or 3 per cent. and in many cases is reported as being negligible.

Unfortunately no satisfactory method has been devised for treating existing structures, such as concrete road surfaces, with molten sulphur, and at best it appears impracticable and extremely expensive.

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DATA FOR PRICING REINFORCED CONCRETE.*

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		s.	d.
Best Washed Sand	per yard	13	6
Clean Shingle, ¾ in. mesh	,,	12	6
,, ,, ⅜ in. mesh	,,	13	6
Thames ballast	,,	10	6
Broken brick (¾ in.)	,,	11	6
Best British Portland Cement (delivered London area).	per ton 53s. to	55	0
Rapid-Hardening Portland Cement	delivered London 10s. per ton extra		
"Super-Cement"	per ton 83s. to	88	0
"Lightning" Brand Aluminous Cement	,, 100s. to	105	6
Ciment Fondu	works f.o.r.	95	0

Boarding for Shuttering—

		Sawn. s.	Sawn. d.	Wrot. s.	Wrot. d.
1 in.	per square	23	6	27	6
1¼ in.	,,	29	6	33	6
1½ in.	,,	35	6	41	0

Sawn Timber for Struts and Supports—

3 in. by 4 in.	from £22 per standard
3 in. by 6 in. and 3 in. by 7 in.	,, £20 ,, ,,

Mild Steel Rods for Reinforcement—

		s.	d.
⅝ in. to 2⅞ in. Rounds	per cwt.	10	6
7/16 in. to ½ in. Rounds	,,	10	9
⅜ in. Rounds	,,	11	0
¼ in. Rounds	,,	12	0

Breeze Slabs per yd. super: 2 in., 1/11; 2½ in., 2/4; 3 in., 2/9; 4 in., 3/6.

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Portland Cement Concrete well mixed in proportion 1 : 2 : 4—

				s.	d.
Do.	do.	in foundation	per foot cube	1	9
Do.	do.	in columns	,, ,,	1	11
Do.	do.	in beams.	,, ,,	2	1
Do.	do.	in floor slabs 4 in. thick	per yard super	5	8
Do.	do.	in floor slabs 5 in. thick	,, ,,	7	0
Do.	do.	in floor slabs 6 in. thick	,, ,,	8	6
Do.	do.	in floor slabs 7 in. thick	,, ,,	9	10
Do.	do.	in walls 6 in. thick	,, ,,	8	2

(Add for hoisting 3s. 6d. per yard cube above ground-floor level. Add for "Ferrocrete" 1s. 10d. per yard cube.)

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From ¼ in. to ⅜ in.	per cwt.	22	6
,, 7/16 in. to ½ in.	,,	21	6
,, ⅝ in. to 2⅞ in.	,,	20	6

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EXTRA LABOUR TO HOOK BENDS: ¼ in., 1d.; ⅜ in., 2d.; ½ in., 2½d.; ⅝ in., 3d.; ¾ in., 3½d.; ⅞ in., 4d.; 1 in., 4½d.; 1⅛ in., 6d.; 1¼ in., 7d. (per bend per cwt.).

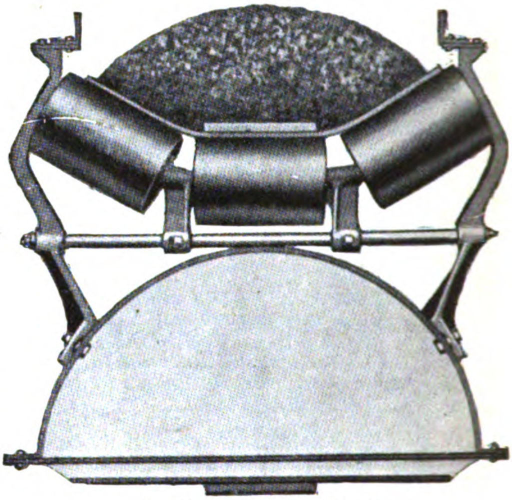
Shuttering—

		s.	d.
Shuttering and Supports for Concrete Walls (both sides measured)	per square	59	0
Centering to Soffits of Reinforced Concrete Floors and Strutting, average 10 ft. high	per square	55	0
Do. do. in small quantities	per ft. super	0	10
Shuttering and Supports to Stanchions for easy removal, average 18 in. by 18 in.	per ft. super	0	11½
Do. do. as last, in narrow widths.	,, ,,	1	1½
Do. do. to sides and soffits of beams, average 9 in. by 12 in.	,, ,,	1	1½
Do. do. as last, in narrow widths.	,, ,,	1	3½
Raking, cutting, and waste to shuttering	per ft. run	0	3
Labour, splay on ditto	,, ,,	0	2
Small angle fillets fixed to internal angles of shuttering to form chamfer	,, ,,	0	3

WAGES.—The rates of wages on which the above prices are based are:—Carpenters and joiners, 1/9½ per hour; Carpenters working on old shuttering, 1/10½; Labourers on building works, 1/4½; Men on mixers and hoists, 1/5½; Bar-benders, 1/5½.

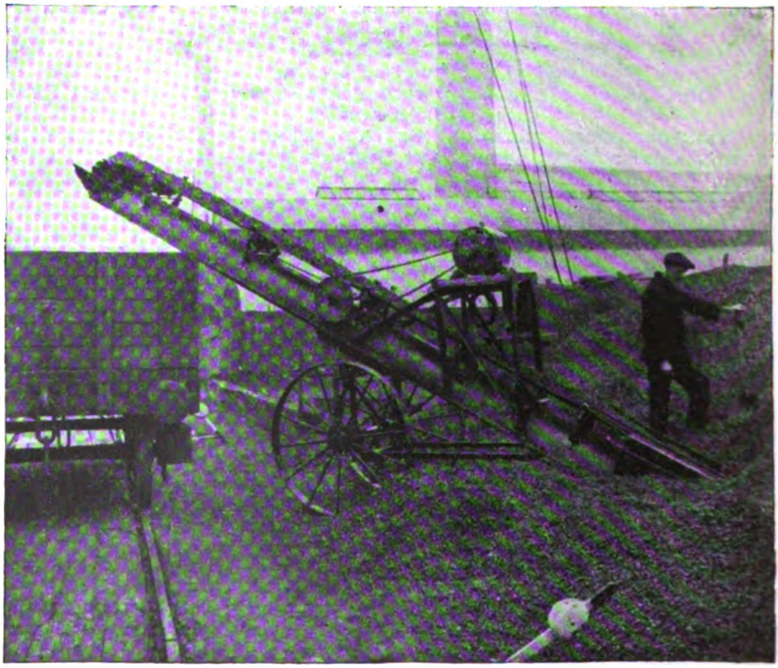
(* This Data is specially compiled for *Concrete and Constructional Engineering*, and is strictly copyright.)

New Portable Conveyor.



Section of Troughing.

A NEW type of portable conveyor for handling loose bulk materials has been put on the market by Messrs. Fraser & Chalmers Engineering Works, of Erith, Kent. The special feature of this machine is the elimination of the usual skirt boards to prevent the materials flowing over the side of the conveyor. This is achieved by troughing the belt, as shown in the sectional view, and it is claimed that this lengthens the life of the belt by at least three times owing to the absence of wear on the edge of the belt. The belt returns flat under the protection of an arch-frame fitted to an automatic belt-cleaning device. The belt has a speed of 200 feet per minute. The standard width of the belt is 16 in., and the lengths of standard machines from 20 to 35 ft.; in the two smaller sizes the engine or motor is arranged over the conveyor as shown in the illustration,—while in the larger sizes the engine is arranged beneath the conveyor.



New Portable Conveyor.

Prospective New Concrete Work.

ABERYSTWYTH.—*Houses.*—The T.C. proposes to build 50 houses on the Penarke estate.

BABINGLEY.—*Bridge.*—The Norfolk County Western Highways Committee has applied for sanction to borrow £1,600 for the construction of a bridge over the Babingley stream near Castle Rising.

BANGOR, IRELAND.—*Concrete Roads.*—The U.D.C. has applied for sanction to borrow £18,000 for reconstructing certain streets in reinforced concrete.

BARNOLDSWICK.—*Concrete Roads.*—The U.D.C. proposes to spend £4,000 on making up a number of streets in reinforced concrete.

BARRHEAD.—*Houses.*—The T.C. proposes to spend £5,750 for a housing estate of 47 acres.

BATH.—*Houses.*—The T.C. has applied for permission to borrow £62,115 for the construction of 122 houses on the Southdown estate.

BOSTON.—*Houses.*—The T.C. has purchased a site on which to erect 104 houses.

BRIDLINGTON.—*Reservoir.*—The T.C. is considering a scheme for the construction of a reservoir.

BRIGHTON.—*Concrete Groyne.*—The T.C. is recommended to construct a concrete groyne opposite the Lagoon. The cost is estimated at £1,600.

CARLISLE.—*Houses.*—Application has been made for sanction to borrow £29,870 for the erection of 76 houses on the Bolcherby estate.

COLCHESTER.—*Paving.*—The T.C. proposes to spend £1,400 on concrete surfacing work at St. John's Street parking place.

CORK.—*Concrete Roads.*—The City Council proposes to reconstruct Fisher's Lane and Thomas Street in reinforced concrete.

CORK.—*Concrete Wharf.*—The Cork Harbour Commissioners propose to spend £2,700 on reconstructing Victoria wharf in reinforced concrete.

FLEETWOOD.—*Road.*—The U.D.C. proposes to construct a 75 ft. road, 1½ miles in length, from the borders of the Fleetwood district to Rossall schools. The scheme is estimated to cost £53,000.

FRINTON-ON-SEA.—*Sea Defence Work.*—The U.D.C. has applied for sanction to borrow £3,620 for sea defence work at Battery Point.

HAILSHAM (SUSSEX).—*Concrete Streets.*—The R.D.C. proposes to construct Victoria Road and Albert Road in reinforced concrete.

HEMEL HEMPSTEAD.—*Concrete Bridge.*—The T.C. proposes to build a reinforced concrete bridge, at an estimated cost of £4,000.

HONICKNOWLE.—*Road.*—The Plympton St. Mary R.D.C. proposes to construct a road on the housing site at Honicknowle, St. Budeaux.

LEIGH, LANCS.—*Houses.*—The T.C. proposes to build 168 houses by direct labour.

MELVERLEY.—*Bridge.*—The Oswestry R.D.C. is considering a proposal to provide a bridge over the River Severn at Melverley.

OLDHAM.—*Houses.*—The Corporation is considering a scheme for the erection of 500 houses.

HOW MUCH
DO
YOU KNOW?

The following is the answer to the ten questions appearing on page xxxii

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ORSETT.—*Houses.* — Application has been made for permission to build 50 houses.

OSSETT.—*Houses.*—The Buildings Committee recommends the Council to apply for sanction to borrow £2,750 for the purchase of the Swithenbank estate for a housing site.

PAIGNTON.—*Houses.*—The U.D.C. proposes to build 30 houses on a site known as Barton Gardens.

ROTTINGDEAN.—*Sea Defence Work.*—The East Sussex C.C. is recommended to carry out sea defence work at Rottingdean, at an estimated cost of £960.

SLOUGH.—*Houses.*—The U.D.C. is considering a scheme for the erection of 152 houses in the Stoke Road district.

SOUTH DUBLIN. — *Reservoir.* — The R.D.C. proposes to spend £29,000 on the construction of a reservoir.

SPENBOROUGH.—*Houses.*—The U.D.C. proposes to build 70 houses on the Gomersal site.

STAFFORD.—*Houses.*—Application has been made for permission to borrow £5,200 for the purchase of a housing site in Stone Road.

TIR-Y-BERTH. — *Bridge.* — The Bedwellty U.D.C. is negotiating with the Gelligaer Council on the question of constructing a bridge over the River Rhymney at Tir-y-Berth.

TYLDESLEY. — *Houses.* — The U.D.C. proposes to build 30 houses on the Sale Lane site.

ULVERSTON. — *Bathing Pool.* — The U.D.C. proposes to construct a bathing pool at Canal Foot.

WHITBY.—*Concrete Promenade.*—The Surveyor has submitted a scheme for developing the cliff frontage. The scheme includes a proposal to construct a 50-ft. wide concrete low-level promenade.

WORCESTER.—*Houses.*—The T.C. has purchased a housing site in Mayfield Road.

Tenders Accepted.

BIRMINGHAM.—*Concrete Houses.*—The City Council has accepted the tender of Messrs. Henry Boot & Sons, Ltd., at £171,690, for the construction of 412 concrete houses at Hall Green.

BLANDFORD.—*Concrete Kerbing and Paving.*—The Corporation has accepted the tender of Mr. F. W. Brickell, Albert Street, Blandford, at £370, for the construction of 720 ft. of 6-in. by 10-in. concrete kerbing, 180 super yards of 2-in. artificial stone paving slabs, and 250 super yards of 2-in. non-slip artificial paving slabs.

CARDIFF.—*Premises.*—The tender of Messrs. E. A. Bond & Co., Beda Road, Cardiff, at £4,749, has been accepted for reinforced concrete work for the new premises for Messrs. D. Duncan & Sons, Ltd. Other tenders submitted: W. S. Thomas & Co., £4,902; F. J. Thomas & Sons, £5,449; W. Symonds & Sons, Ltd., £5,579; F. C. Williams, £5,845; D. Davies & Sons, £5,889; Tucker Bros., £5,898; Watts & Gale, £6,170; W. Thomas & Co., £6,640; S. & I. Williams, £6,826; H. Jones, £7,982.

CARLISLE. — *Concrete Houses.* — The City Council has accepted the tender of Messrs. John Laing & Son, Ltd., at £8,192, for the erection of 20 concrete houses on the Blackhall Road estate.

CHESTER.—*Concrete Sewers.*—The T.C. has accepted the tender of Messrs. G. Clarke & Sons, Ltd., Bristol Street, Hulme, Manchester, at £10,555, for the construction of concrete pipe sewers, together with concrete and brick manholes.

DEWSBURY.—*Concrete Tank and Floors.*—The Dewsbury and District General Infirmary Board has accepted the tender of Messrs. S. MacFarlane, Ltd., Leeds, at £13,800, for the construction of a concrete water tank and floors.

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Falmouth.—*Sewerage Works.*—The Corporation has accepted the tender of Messrs. A. J. Steer, Ltd., Carfrae Terrace, Plymouth, for the construction of about 400 ft. of 18-in. concrete tubes surrounded with concrete to form a storm overflow.

Kingston (I.O.W.)—*Concrete Raft.*—The Electric Light & Power Co. has accepted the tender of Messrs. F. Bevis, Ltd., at £1,890, for the construction of a reinforced concrete raft.

Merthyr.—*Concrete Water Tank.*—The G.W. Railway Co. has accepted the tender of Messrs. Johnson's Reinforced Concrete Co., Ltd., for the construction of a concrete water tank at Merthyr.

Sandown (I.O.W.)—*Concrete Groynes.*—The U.D.C. has accepted the tender of Messrs. Sadler & Co., Cosham, Hants, at £192, for the construction of three reinforced concrete groynes.

Southampton.—*Concrete Dolphins.*—The Harbour Commissioners have accepted the tender of Mr. A. E. Farr, at £1,500, for the construction of three reinforced concrete dolphins.

Stonehaven.—*Reservoir.*—The T.C. has accepted the tender of Messrs. J. Scott & Sons, Ltd., Aberdeen, at £277, for reinforced concrete work in connection with lining the inside walls and floors of the Slug Road reservoir. Other tenders submitted: Yorkshire Hennebique Contracting Co., Ltd., £650; Grays Ferro Concrete Co., Ltd., £530; C. M'Donald & Sons, £415 17*s.* 6*d.*; James Leith, £356; Henderson & Milne, £259 12*s.* 6*d.*

Wembley. — *Concrete Sewers.* — The U.D.C. has accepted the tender of Messrs. Moffatt's General Construction Co., Ltd., 26, Hart Street, W.C.2, at £2,766, for the construction of about 650 yds. of concrete tube sewers, complete with manholes. Other tenders submitted: F. Jackson, £2,778; C. Ball, £2,785; J. B. Edwards & Co., Ltd., £2,787; Mears Bros., £3,089; R. H. Powis, £3,097; T. Muirhead & Co., Ltd., £3,097; T. B. Gulliver, £3,360; W. Muirhead, Macdonald Wilson & Co., Ltd., £3,509; T. D. Petrette, £3,539; Shadbolt & Davis, £3,581; J. Moffatt, £3,923; Crawford Bros., £3,951; R. H. Hartley & Co., Ltd., £4,140; H. G. Sharp, £4,212; M. Vine, £4,632.

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WEMBLEY. — *Concrete Road.* — The U.D.C. has accepted the tender of Messrs. J. B. Edwards & Co., 180, Piccadilly, W., at £61,110, for reconstructing in reinforced concrete and widening about 2,850 yards of Watford Road. Other tenders submitted: T. B. Gulliver, £65,529; Shadbolt & Davies, £67,356; R. H. Powis, £67,759; G. P. Trentham, Ltd., £67,994; G. Wimpey & Co., Ltd., £70,067; J. Mowlem & Co., Ltd., £70,474; W. H. Wheeler & Co., £70,954; A. Graham, £71,024; W. Jones & Sons, Ltd., £71,213; T. Muirhead & Co., Ltd., £71,473; M. Vine, £71,502; Mears Bros., £71,513; W. Moss & Sons, Ltd., £71,949; C. Ball, £72,613; J. Moffatt, £73,309; J. W. Adams, £73,432; Sir Wm. Prescott & Sons, Ltd., £73,434; T. D. Pedrette, £73,888; Chittenden & Simmons, Ltd., £74,289; Moffatt's General Construction Co., Ltd., £74,614; W. Muirhead, Macdonald Wilson & Co., £75,063; W. Griffiths & Co., Ltd., £75,888; F. Jackson, £76,777; Walker Weston Co. Ltd., £78,373; J. Cronk & Sons, £81,281.

Trade Notices.

"Blaw-Forms."—An arrangement has been come to by which the English interests of the Blaw-Knox Company of Pittsburg, U.S.A., have been taken over by Messrs. Milliken Brothers and Blaw-Knox, Ltd., of Wellington House, Strand, W.C.2. The steelwork and engineering portion of the business of Christmas & Walters (Caxton House, London, S.W.1), however, is being continued, and will as heretofore be carried out by them.

Ransome Plant.—Messrs. Ransome & Rapier, Ltd., of Ipswich, have issued a new catalogue giving particulars of their "Runabout," "Featherweight," "Lightweight," "Middleweight" and rotary drum mixers, and also announce a substantial reduction in the price of these machines.

B.R.C. Leeds Representative.—Major H. A. Butterfield, A.M.Inst.C.E., P.A.S.I., has been appointed Roads Representative for The British Reinforced Concrete Engineering Co., Ltd., for the Leeds Area. The address of the Leeds Office is 5, East Parade.

Concrete Tramway Sleepers.

THE Melbourne Tramways Board have, states "The Railway Review," just uncovered a number of concrete sleepers which were laid down as long ago as 1914 as an experiment. They have been in the ground continuously for 13 years and are now found to be as sound in condition as when they were first laid. The wooden sleepers in a neighbouring length of track have had to be renewed on account of deterioration. The technical staff of the Tramways Board is looking carefully into the matter with a view to further use of concrete sleepers.

Recent Patent Applications.

267,484.—K. Piehler: Mixing concrete.
274,537.—A. Haussens: Moulding concrete blocks.
274,699.—Irving Iron Works Co.: Reinforced concrete flooring.
275,680.—F. A. Robins and F. M. Taylor: Concrete blocks.
275,894.—R. Hahn: Concrete mixers.

New Company Registered.

HAMILTON SLABS, Ltd. (224379). Registered September 12. 233, Clapham-road, S.W.9. Manufacturers of concrete partition slabs, etc. Nominal capital: £100 in £1 shares. Permanent directors: W. L. Cook, 233, Clapham-road, S.W.9; A. W. Mills, 53, New Broad-street, E.C.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XXII. No. 11. LONDON, NOVEMBER, 1927.

EDITORIAL NOTES.

An Opening for Concrete Poles.

THOSE interested in furthering the uses of concrete will have noted an announcement in the Press last month to the effect that the Central Electricity Board, which is preparing schemes for the supply of electricity in Great Britain from super-power stations, has decided to use steel towers, or poles, to carry transmission lines. We understand, however, that so far it has only been definitely decided to make use of these steel towers for the high-tension distribution in connection with the Scottish scheme, and that the type of pole to be used for the low-tension transmission in Scotland and for both high-tension and low-tension transmission in the other areas has not yet been agreed upon. The decision to use these steel towers was, we believe, arrived at solely because of the urgency with which they were required. Not that, with the use of modern cements, concrete poles cannot be made and erected expeditiously, but because of the difficulty experienced in procuring data on the design of reinforced concrete poles of a height up to 62 ft. and to carry transmission lines spanning up to 1100 ft. Such poles have, of course, been in use on the Continent for many years, and in France particularly they are used to such an extent that a standard specification for their design is in existence. But as we understand the position the Board did not consider the available data sufficient on which to embark on the manufacture of over a thousand poles needed for the high-tension transmission in connection with the Scottish scheme alone.

It is no reflection on the few firms who have experimented with, or made, reinforced concrete poles to say that this country has lagged far behind other countries in the development of the reinforced concrete transmission pole. This is largely due to the lack of support from users of such units, but it cannot be denied that the concrete industry as a whole has been singularly neglectful of the possibilities of concrete poles. There is now a unique opportunity available for the use of tens of thousands of reinforced concrete poles in heights of from 30 ft. to 60 ft. and upwards, and to carry spans of from 300 ft. to over 1,000 ft. The permanence of concrete needs no emphasis, neither does its economy in maintenance ; the chief stumbling-block seems to be standardisation of a design which the responsible authorities can be quite sure will be satisfactory. It must be admitted that it is a great responsibility for any public body to embark on the manufacture and erection of such a large number of concrete transmission towers or poles without every assurance that they will be in all ways satisfactory. We believe certain firms have already been approached on the subject of manufacturing reinforced concrete poles for some of these schemes, and hope it will be possible to convince the Board and its advisers that there is no reason why reinforced concrete structures that have proved efficient and satisfactory in other countries should not be equally efficient and satisfactory here.

Architectural Detail Cast in Formwork.

IN this number we illustrate an interesting example of architectural detail cast *in situ* with the structural members by the insertion of moulds inside the main shuttering. The simpler method of ordering pre-cast decorative units from cast stone makers has no doubt been to some extent responsible for this method of forming architectural detail in concrete; the better finish, and the greater simplicity of using special facing mixtures, are other factors that have favoured the use of precast ornamental units. These factors have greater weight when cast stone made to represent natural stone is, for the sake of economy, used for detail on natural-stone façades, or when a representation of natural stone is needed for the dressings to a brick building.

But when concrete detail is desired on a concrete building, as in the case referred to, the necessity of matching natural stone does not exist. No special mixes or surface treatments are required to make a gravel concrete to represent gravel concrete ; the truest representation must be obtained by using the same mix and treating the whole surface, including the moulded detail, in exactly the same way. With this method, also, the ornamental detail is monolithic with the structural members, which surely is the right treatment of a plastic material such as concrete. The garage illustrated is a very successful example of this method of construction, and the figures given of the extra cost of shuttering and rubbing with carborundum show that it has the merit of economy.

Supplying Ready-Mixed Concrete.

WE have previously referred to the increasing business being done in the United States in the supply of ready-mixed concrete from a central mixing plant. This has led to a new development in the shape of tipping lorries equipped as concrete mixers in which the materials are mixed while they are actually being transported from the central storage plant to the job on which they are required. We understand that this method of delivering ready-mixed concrete is now in use in Washington, California and Oregon, and that its popularity is spreading.

The body of the truck is the shape of an open trough mixer, built of steel, and the truck is fitted with a tipping arrangement so that the mixed concrete may be discharged from the end. Mixing is by paddles, or spades, on a revolving shaft along the centre of the body, and operated from the engine. The standard mixer trucks have a capacity of 2½ cubic yds. of mixed materials, and are fitted with water tanks and automatic water control apparatus.

Torsional Strength of Reinforced Concrete.

INTERESTING TESTS BY JAPANESE ENGINEERS.

By Takenosuke Miyamoto.

Civil Engineer in the Bureau of Public Works, Home Department, Tokio.

The theory of torsion has been, since the beginning of the last century, published by several elasticians, among whom Navier, Poisson, Cauchy, Saint-Venant, in France, and Wertheim, Grashof, Hermann, Föppl, Henneberg, Prandtl, Weber, in Germany, are the most prominent; and since that time the torsional strength of materials, especially of cast iron, hard lead, and mild steel, has been tested in several countries. All these publications are valuable for solving this difficult but interesting problem.

Torsion of concrete and reinforced concrete members has, however, until recently been left untouched, primarily because it is undoubtedly a very rare occurrence that torsional stresses arise in any parts of actual constructions. Torsion of concrete is a problem of less importance than its bending or compression. Reinforced concrete screw-piles have been recently used, and although these are exceptional cases of primary torsional stresses, yet we should not forget the occurrence of torsional stresses in nearly all constructional parts as secondary stresses, especially in such countries as Japan where earthquakes are frequent and severe.

Former tests with respect to torsional strength of concrete, plain and reinforced, made in foreign countries are as follows:

(1) Tests by Professor E. Mörsch (Stuttgart), 1903, with 8 test-pieces of circular section 26 cm. in diameter, of plain concrete and concrete reinforced with spirals.

(2) Tests by Professor Mesnager (Paris), 1903, with 2 test-pieces of circular section 10·7 cm. in diameter, longitudinally reinforced.

(3) Tests by Professor C. Bach (Stuttgart), 1911, with 37 test-pieces of circular section 40 cm. in diameter, quadratic section 30 by 30 cm. and rectangular section 42 by 21 cm., of plain concrete and concrete reinforced with longitudinal bars, longitudinal bars and rings, and longitudinal bars and spirals.

(4) Tests by Professor A. Föppl (München), 1911, with 15 test-pieces of circular section 10 cm. in diameter, of plain and longitudinally reinforced concrete.

(5) Tests by Professor C. R. Young (Toronto), 1911, with 12 test-pieces of quadratic section 12·7 by 12·7 cm., and rectangular sections 12·7 by 19·05 and 12·7 by 25·4 cm., of plain concrete and concrete reinforced with longitudinal bars, and also with longitudinal bars as well as spirals.

(6) Tests by Professor O. Graf (Stuttgart), 1921, with 17 test-pieces of circular section 40 cm. in diameter, of plain concrete and concrete reinforced with longitudinal bars, rings, longitudinal bars and rings, and spirals.

Tests.

These experiments have drawn attention to the subject, but they are far from being complete. It is theoretically proved that shearing stresses arise in cross section as well as longitudinal section of a member which is subjected to torsion, and, as a result of these shearing stresses in two right-angle directions, principal tensile and compressive stresses occur in the direction of 45 deg. to the axis. In the case of mild steel the member is actually sheared off transversely, so that the torsional strength is the same as the shearing strength. But in case of such materials as cast iron and concrete, the tensile strength being less than the shearing strength, the torsional destruction occurs in directions of 45 deg. to the axis, due to the principal tensile stresses.

These statical relations justify the experimental facts from the former tests, such as that longitudinal bars or rings, when embedded alone in concrete, possess no influence upon torsional strength; the combination of these two types of reinforcement increases the torsional strength more or less above that of plain concrete; and the most effective reinforcement for torsion is spiral, which is embedded in directions of 45 deg. in such a way that it is stressed in tension when subjected to torsion.

The experiments undertaken by the author were designed to study (1) the torsional strength of plain concrete; (2) a law governing distribution of shearing stress in a cross section; (3) modulus of elasticity of concrete for shearing; and (4) effects of spiral reinforcements placed at different angles with the axis.

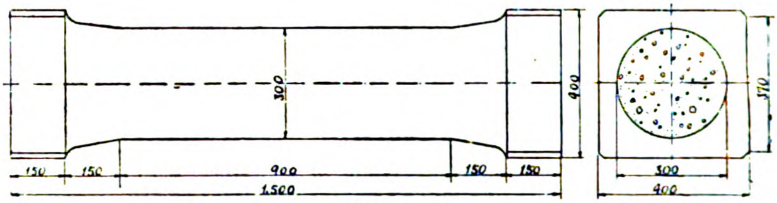


Fig. 1.

The tests were planned and directed by the author and carried out in the laboratory of testing materials in the Home Department, Tokio, with the assistance of several colleagues. They consisted of torsional tests with 16 plain concrete and 78 reinforced concrete circular cylinders.

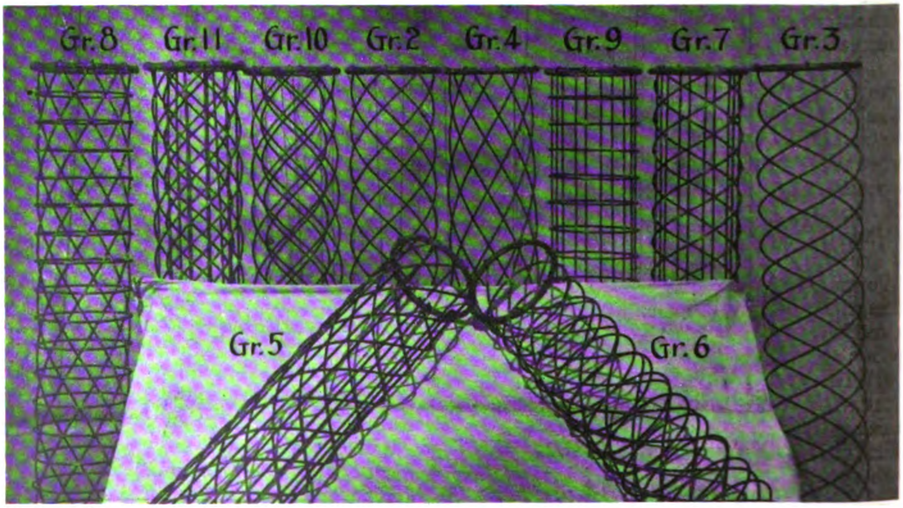


Fig. 2.

Group 1.—Tensile tests of plain concrete were made with 12 test-pieces, compressive and shearing tests with 6 cylinders each. Test-pieces for torsion (shown in *Fig.* 1) are 1·5 m. in total length, and 30 cm. in diameter in the middle cylindrical portion, provided with enlarged rectangular heads, 40 by 40 cm. in section and 15 cm. in length, at both ends.

The 78 reinforced concrete test-pieces were classified into 10 groups, according to the type of reinforcement, as follows:

Group 2.—8 pieces with 7 spirals which sustain an angle $\beta = 45$ deg. with the axis;

Group 3.—8 pieces with 5 spirals, where $\beta = 60$ deg.;

Group 4.—8 pieces with 9 spirals at an angle $\beta = 30$ deg. with the axis;

Group 5.—8 pieces with seven 45 deg.-spirals as well as 10 longitudinal bars;

Group 6.—8 pieces with seven 45 deg.-spirals as well as 18 rings;

Group 7.—8 pieces with five 60 deg.-spirals and 10 longitudinal bars;

Group 8.—8 pieces with nine 30 deg.-spirals and 18 rings;

Group 9.—8 pieces with 10 longitudinal bars as well as 18 rings;

Group 10.—8 pieces with 7 outer and 5 inner 45 deg.-spirals;

Group 11.—6 pieces with the same double spiral reinforcement as *Group* 10 and 6 longitudinal bars added to each spiral.

All reinforcing bars were 6·35 mm. in nominal diameter. In order to compare easily the effectiveness of different types of reinforcement, the quantity of steel for a unit length of test-piece was taken equal or twice as much, except in *Groups* 10 and 11. Several reinforcements are shown in *Fig.* 2.

Materials.

The cement was a product of the Asano Portland Cement Co., to the official specifications of the Department of Agriculture and Commerce. The following are some special aspects of this cement:

Fineness.—Residue upon sieve of 900 meshes per sq. cm., 0·002 per cent.; Do. upon sieve of 4,900 meshes per sq. cm., 1·602 per cent.

Specific gravity.—3·077.

Tensile strength.—With neat cement, 64·6 kg. per sq. cm. at 7 days. With 1 : 3 mortar, 24·3 kg. per sq. cm. at 7 days; at 28 days, 30·9 kg. per sq. cm.

Compressive strength.—With 1 : 3 mortar, 268·5 kg. per sq. cm. at 28 days.

The fine and coarse aggregates were clean and hard grained sand and gravel from the river Tama, and the results of their sieve analysis were as follows:

RESIDUE UPON SIEVES.

Sieve.	Gravel.	Sand.	Mixed in Ratio 1 : 2.
1 in.	—	—	—
¾ in.	2·7	—	1·8
⅜ in.	50·1	—	33·4
No. 4	94·0	0·4	62·8
8	100·0	3·6	67·9
16	—	21·0	73·3
30	—	56·6	85·5
50	—	79·7	93·2
100	—	98·2	99·4
Fineness modulus	—	—	5·177

All reinforcing bars were mild steel of the nominal diameter 6·35 cm. From tests it was proved that the average diameter was 6·42 cm. and the tensile strength 3,900 kg. per sq. cm.

Test-pieces and Testing Machines.

Test-pieces for torsion were made in wooden forms (shown in *Fig.* 3), and those for tension, compression and shearing, in usual cast-iron forms.

The concrete used was 300 kg. cement to 400 litres sand and 800 litres gravel. This proportion corresponds to 1 : 2 : 4 mix, when the unit weight of the cement is taken as 1,500 kg. per cubic metre. The unit weight of the sand was about 1,600 kg. per cubic metre, and that of the gravel about 1,650 kg. per cubic metre.

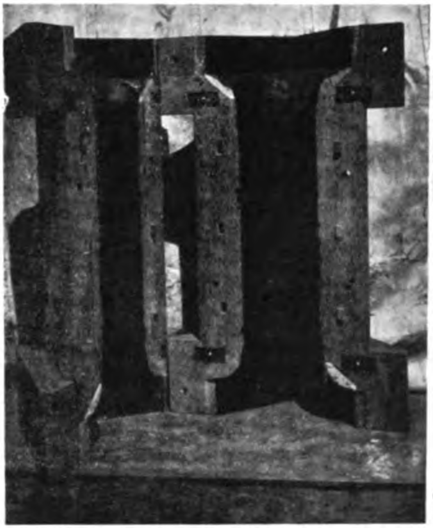


Fig. 3.

Measurement of all materials was by weight.

The volume of a test-piece for torsion was about 140 litres, and the following materials were used for each test-piece: 39·6 kg. cement, 84·5 kg. (52·8 litres) sand, 173·6 kg. (105·6 litres) gravel, and 26·8 kg. water. Aggregates were weighed in perfectly dry condition.

The water content corresponds to 9 per cent. of all dry materials including cement, but sometimes it varied between 9 and 9·5 per cent. according to weather. The consistency of the mix was measured by the slump test, and the results varied between 12·3 and 15·2 cm., the average being 13·5 cm., a cone 30 cm. in height being employed.

The concrete was placed in the moulds in layers not thicker than 10 cm. All test-pieces remained in the moulds for two days, with the top surface covered with wet straw matting, after which they were removed from the moulds and the cylindrical surface covered immediately with straw matting which was kept wet during total curing time (as shown in *Fig.* 4). On the seventh day the test-pieces were laid horizontally, and in this condition they remained until tested. Test-pieces were, with a few exceptions, tested at an age of 45 days.

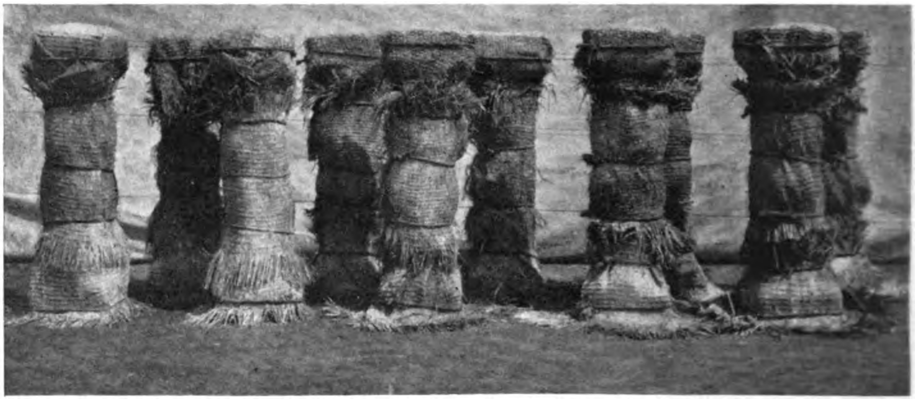


Fig. 4.

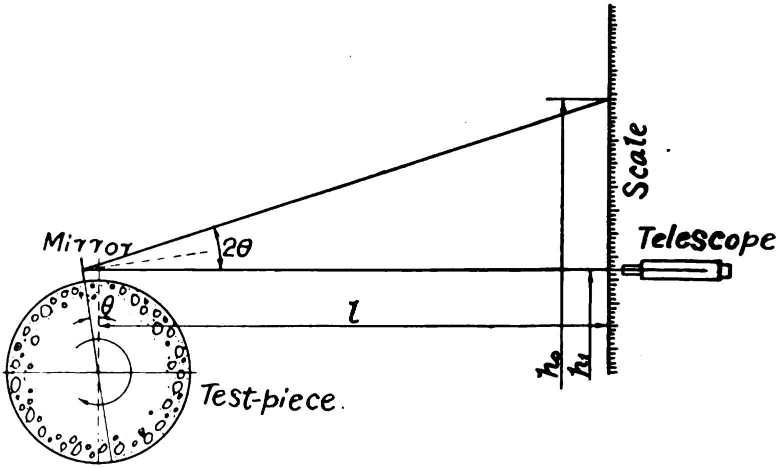


Fig. 5.

By torsional tests the following were observed:

(1) Torsional moment at the first crack;

(2) Maximum torsional moment;

(3) Torsional angle measured at two points in the middle cylindrical portion of the piece and 50 cm. distant from each other.

For measurement of torsional angles two mirrors were fixed to the test-piece, and two telescopes and surveying instruments used. The angle θ at any load condition could be found by the calculation of tan 2θ. *Fig.* 5 shows the arrangement of angle-measurement.

The torsion machine was designed and manufactured specially for this purpose. It was provided with two cast-iron caps, square in section, for supporting both heads of the test-piece. One of these caps was made so that it would slide parallel to the axis when loading and unloading, but was rigidly fixed when they were distorted. The other cap was rigidly connected to the machine shaft, and revolved with it. To this shaft was fixed a sector wheel, around which a wire rope of 12·7 cm. periphery ran over to a universal machine of 100,000 kg. capacity, so that the tractive force developed by the universal machine was transformed into the twisting force in the torsion machine, the sector wheel serving to keep an arm length of torsional moment constant and equal to 40 cm. The torsion machine is shown in *Fig.* 6, and a reinforced concrete test-piece under torsion in *Fig.* 7.

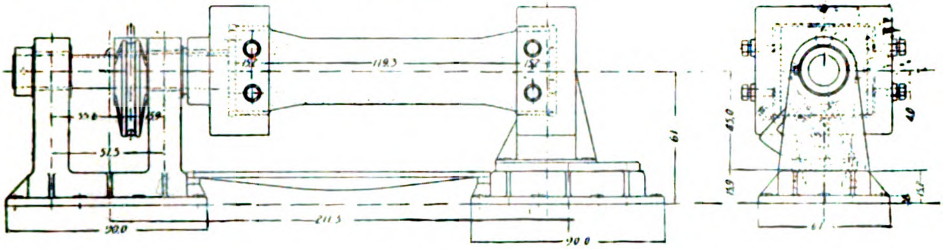


Fig. 6.

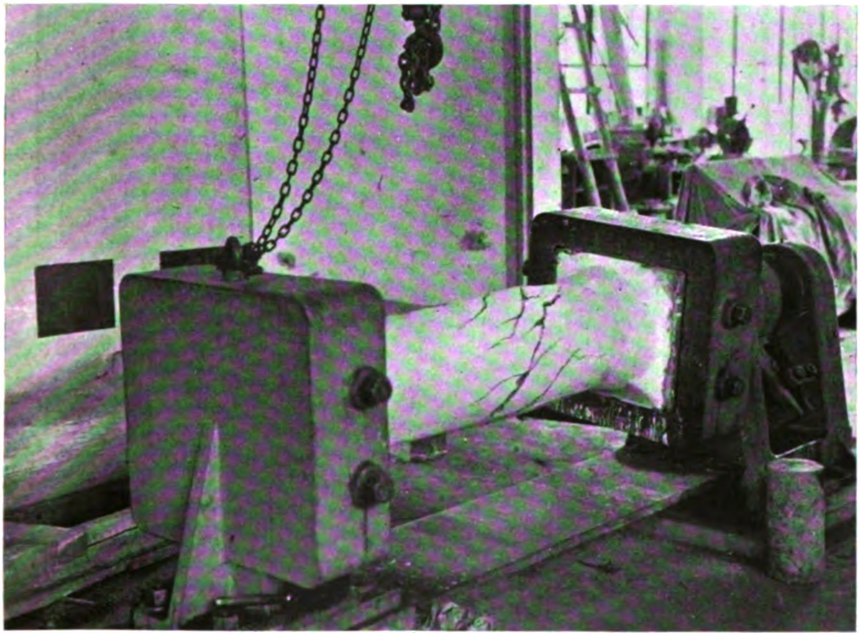


Fig. 7.

Strength of Concrete.

The concrete used for the tests had the following strength at 45 days:

Compressive strength, 119 to 136 kg. per sq. cm., with an average of 128 kg. per sq. cm. Tensile strength, 9·3 to 15·7 kg. per sq. cm., with an average of 12·4 kg. per sq. cm. Shearing strength, 45·2 to 65·9 kg. per sq. cm., with an average of 58·1 kg. per sq. cm.

From these results one can easily expect that the torsional failure of concrete occurs in helical surfaces at an angle of 45 deg. to the axis, due to the principal tensile stress, and not in transverse sections due to the shearing stress, and this expectation was realised in the experiments to be mentioned below.

Tests with Plain Concrete.

Four of the 16 plain concrete test-pieces were put under torsion, four were subjected to repetition of loading and unloading, and the remainder tested in the same manner as reinforced concrete pieces by increasing the load slowly up to the maximum. The results of the principal tests with the remaining 12 pieces were as follows :

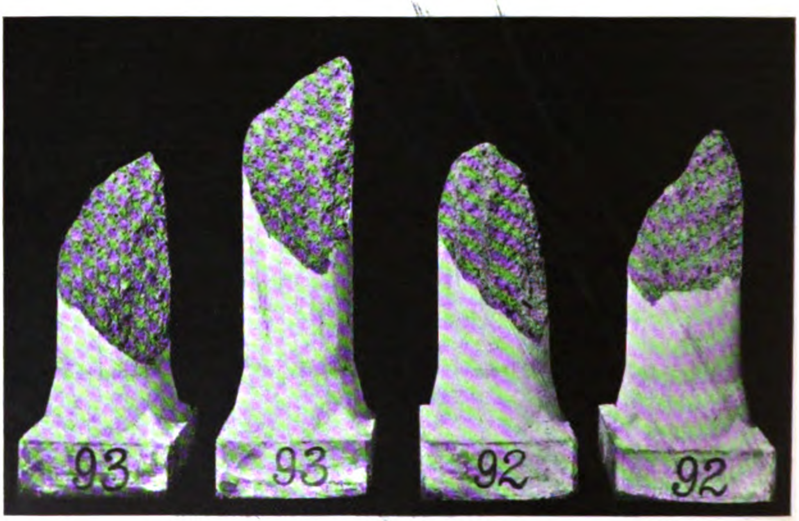


Fig. 8.

(1) For constantly increasing load, the maximum torque $M_t = 120{,}860$ cm. kg., for an average of 8 tests ; (2) For repeated load, $M_t = 98{,}400$ cm. kg., for an average of 4 tests. The results show the fatigue of concrete due to the repeated load.

From tests with plain concrete it was recognised that the failure followed in a helical line running upon the cylindrical surface of the piece ; and that the torsional moment at the first crack was a maximum ; or, in other words, the failure occurred suddenly and at the same time with the first crack. *Fig.* 8 shows plain concrete pieces after being twisted off.

Tests with Reinforced Specimens.

The reinforced concrete test-pieces were classified into 3 classes, Class A comprising Groups 2 to 4 ; Class B, Groups 5 to 9 ; and Class C, Groups 10 and 11.

In Class A the specimens were reinforced with spirals at angles of 45 deg., 60 deg., and 30 deg. respectively with the axis. The steel ratio was almost equal for all three classes.

In Class B, the types of reinforcements were (1) spirals and longitudinal bars, (2) spirals and rings, and (3) longitudinal bars and rings, and the steel ratio was taken twice that of Class A for all specimens without regard to the different types of reinforcements.

In Class C the reinforcements were double spirals, which served for comparison of the effect of steel embedded in different positions in cross section ; the steel ratios were different from each other, as well as from those in Classes A and B.

The following is the summary of the results of tests with these reinforced concrete pieces, M_t representing the torque at the first crack, and M_t' the maximum torque.

Class.	Group.	No. of tests.	Steel ratio (%).	Torque at the first crack. M_t (cm. kg.).	comp.	Maximum M_t' (cm. kg.).	Torque comp.
—	1	8	0	120,860	1·00	120,860	1·00
A	2	8	0·709	141,600	1·17	191,900	1·59
	3	8	0·716	137,900	1·14	189,250	1·57
	4	8	0·745	131,300	1·09	177,850	1·47
B	5	8	1·425	144,400	1·19	201,050	1·66
	6	8	1·418	159,850	1·32	209,850	1·74
	7	8	1·432	141,800	1·17	201,200	1·66
	8	8	1·454	151,950	1·26	208,600	1·73
	9	8	1·425	120,750	1·00	135,100	1·12
C	10	8	1·217	149,000	1·23	249,850	2·07
	11	6	2·076	150,000	1·24	265,800	2·18

From tests with reinforced concrete it was observed generally that,

(1) The torque at the first crack was evidently greater than in case of plain concrete;

(2) The maximum torque was considerably greater than that at the first crack;

(3) The cracks ran, as in case of plain concrete, in helical lines which ascend at an angle of about 45 deg.;

(4) The first crack was so fine that it could be recognised only by the most careful search, but sometimes it extended over the total periphery of the test-piece;

(5) With increased load the crack extended rapidly and a great many new cracks appeared;

(6) In the neighbourhood of the maximum torque the cracks developed most rapidly and increased their width;

(7) The cracks developed when the load was not increased and kept still at any given stage;

(8) At the maximum torque some cracks opened further, for example, until the width was 3 mm. or more; in this case the remaining portion of the piece became less stressed, cracks running in decreasing width;

(9) At the maximum torque the resistance of the piece was not exhausted;

(10) Upon continuation of twist, the load descended gradually from its maximum stage, even though the development of cracks continued simultaneously, until the concrete lying outside the reinforcement became separated;

(11) In no cases could reinforcing bars be stressed up to the breaking strength.

It is evident, from the theoretical point of view, that 45 deg. spiral reinforcement must be the most effective for increasing the torsional strength of concrete, as it is able to resist directly the principal tension in a direction of 45 deg., and this may be observed from the results of the tests. At the same time it may be reasoned that longitudinal bars or rings added to 45-deg. spirals must be redundant on the basis of statics, but as a matter of fact they can exert some influences upon hindering twisting of the piece.

In comparing the test-pieces in Groups 2 and 10, the surplus torque must be concluded as developed by inner spirals, and thus it was calculated from results of tests that the stresses in reinforcements vary in direct proportion to the distance from the axis.

Figs. 9 to 12 show reinforced concrete test-pieces in Classes A to C after twist; *Fig.* 9 represents those in Group 2, Class A; *Fig.* 10 those in Group 7, Class B; *Fig.* 11 those in Group 10, and *Fig.* 12 those in Group 11, both in Class C.

The test-pieces shown in *Fig.* 12 are examples of continued twist over the maximum torque, as a result of which the concrete outside the reinforcement became loose and dropped off as shown.

Twisting Angles.

The twisting angles were observed and calculated in the case of nearly all the plain and reinforced concrete test-pieces, and the specific angles θ (for 1 cm.) were compared. Generally no difference of the angle was observed due to the different types of reinforcements, and there seemed to be no material diminution of the angle in reinforced concrete in comparison with a plain concrete test-piece. From these results, and those of the former tests, it may be said that the reinforcement, irrespective of the type, has little influence on twisting angles.

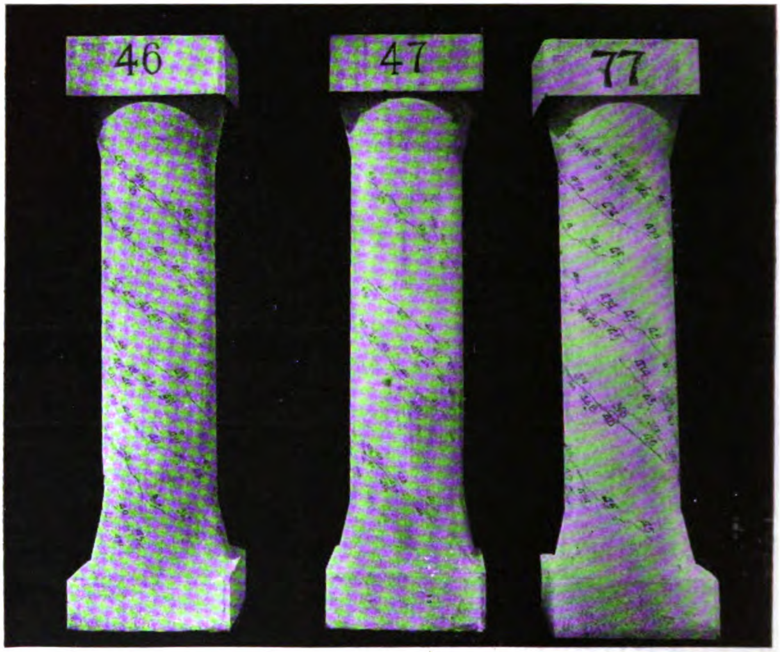


Fig. 9.

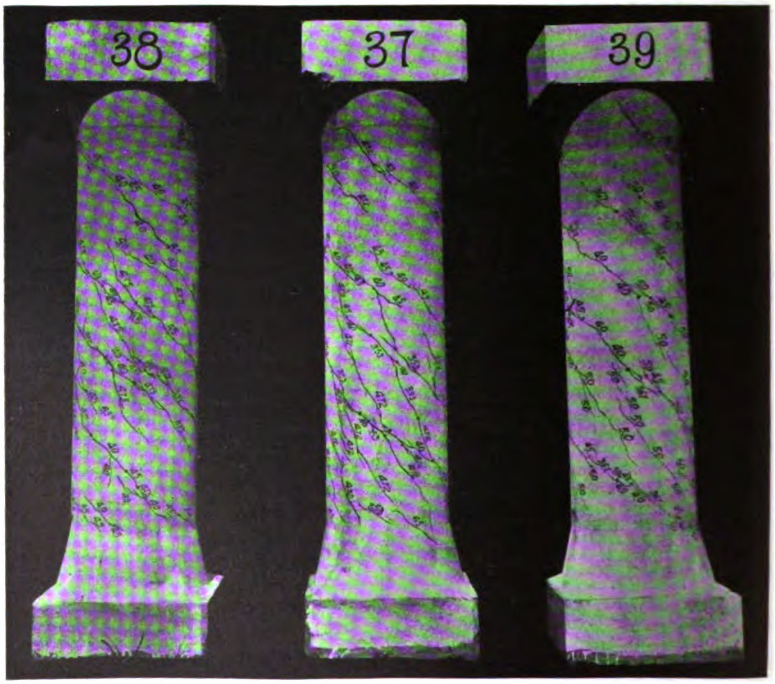


Fig. 10.

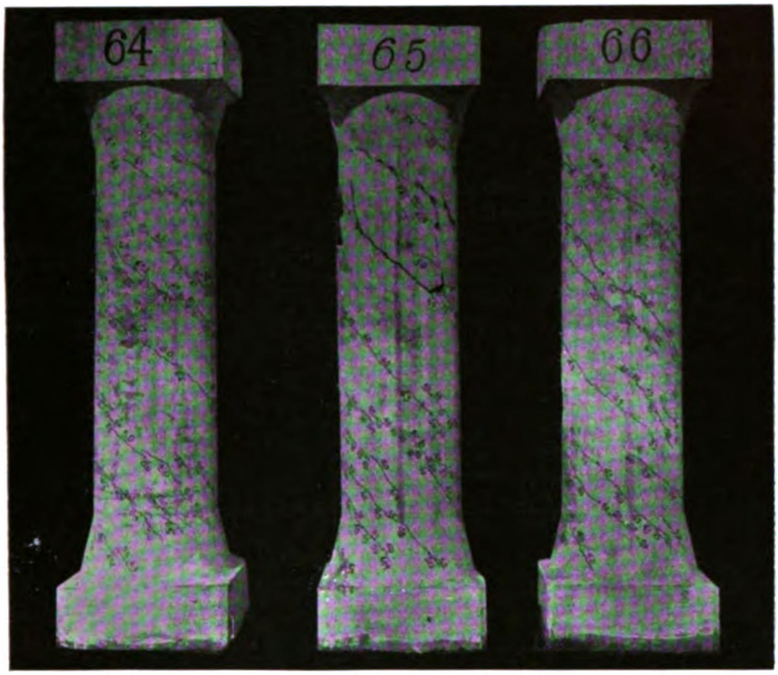


Fig. 11.

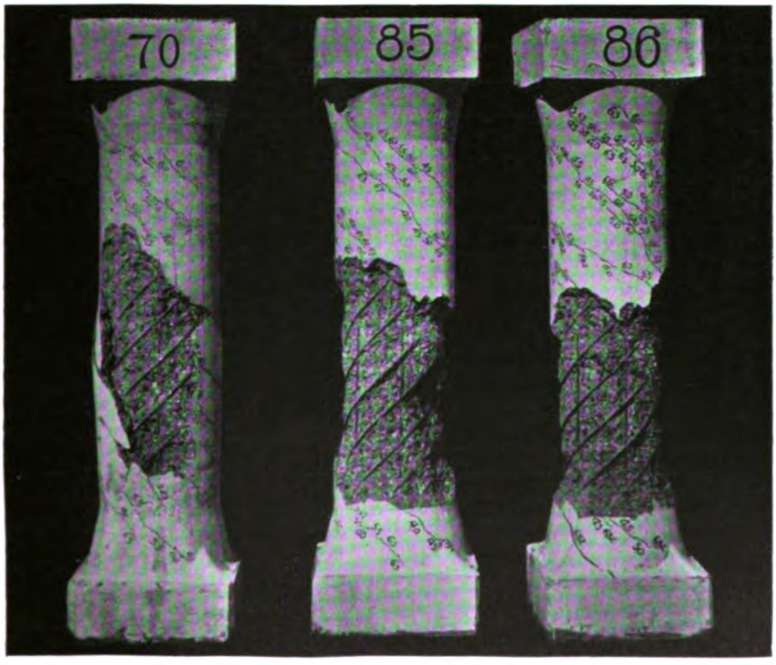


Fig. 12.

Fig. 13 shows the relation between torques and specific twisting-angles in test-pieces No. 94 (Group 1, plain concrete), No. 71 (Group 8, reinforced concrete) and No. 70 (Group 11, reinforced concrete).

Distribution of Shearing Stresses and Modulus of Elasticity.

In the case of a perfectly elastic body, the shearing stress in circular cross section of a twisted piece is subjected to a uniform varying distribution, from nil at the centre to a maximum at the circumference, as represented by the following formula :

$$f_s = \frac{2}{\pi}\frac{M_t}{r^3}$$

where f_s is a max. shearing stress intensity, M_t torque, and r the radius of cross section.

This formula may be applied to nearly all metals until the elastic limit of the material, but not beyond this limit, and in the neighbourhood of the failing point it is more reasonable to suppose that the shearing stress distributes uniformly upon every radius, thus

$$f_s = \frac{3}{2\pi}\frac{M_t}{r^3}$$

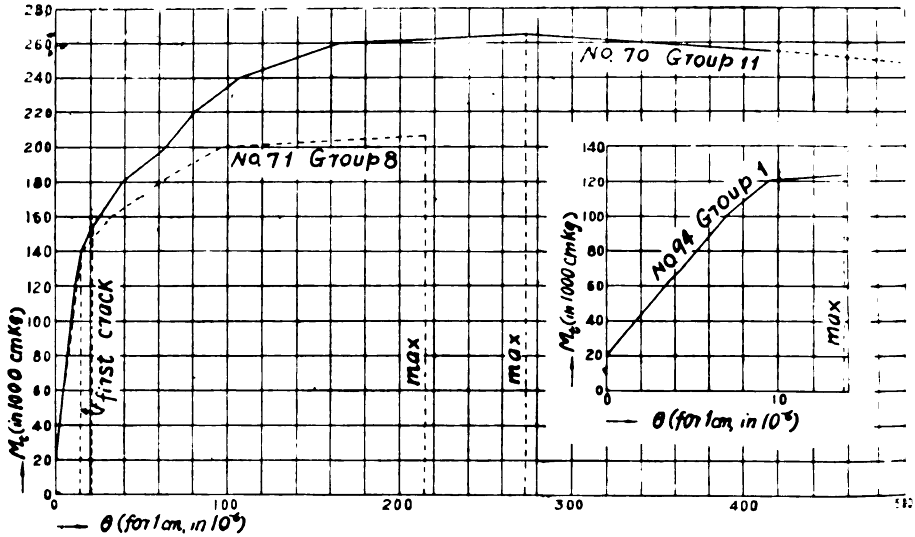


Fig. 13.

This supposition has been justified by results of former tests with steel and cast iron. In the case of such brittle materials as concrete or stone the stress varies in a curve which may be assumed as a parabola. Thence

$$f_s = \frac{\eta}{r^3}\frac{M_t}{4\pi}.$$

On application of this last formula to the result of plain concrete, in which case the mean value of the maximum torques is 120,860 cm. kg., we have the following value of the maximum shearing stress intensity :

$$f_s = \frac{\eta}{4\pi}\frac{120{,}860}{15{\cdot}00^3} = 19{\cdot}9 \text{ kg. sq. cm.}$$

On the other hand, from the assumption of parabolic stress distribution, we get the following formula between the modulus of elasticity, the torque, and the specific twisting angle :

$$G = \frac{f_s}{\theta r} = \frac{\eta}{4\pi}\frac{M_t}{\theta r^4}.$$

The following table is the result of calculation of the modulus of elasticity in the case of these tests by means of the above formula.

Loading stage. M_t (cm. kg.).	f_t (kg./sq cm.)	Spec. twist. angle. (10^{-6})	Mod. of elasticity. G (kg./sq. cm.)
20,000	3·3	1·5	146,900
40,000	6·6	3·1	142,100
60,000	9·9	4·9	136,500
80,000	13·3	6·8	130,600
100,600	16·6	9·0	122,400

Thus the modulus of elasticity of concrete is not constant but decreases as the stress intensity increases, as has usually been observed in the former German tests.

Conclusions.

From the results of the tests the following may be concluded :

(1) The failure of plain concrete as well as the cracks of reinforced concrete follow, without exception, in helices of direction of 45 deg.

(2) Among the pieces in Groups 2 to 4, where an equal steel ratio is adopted, 45 deg. spiral reinforcement is the most effective and thus the most economical.

(3) 30 deg. spiral reinforcement is the least effective, the 60 deg. spiral reinforcement lying between these two.

(4) Longitudinal bars or rings added to 45 deg. spirals are able to increase more or less the torsional resistance, although their statical action cannot be calculated.

(5) In this case the rings are more effective than the longitudinal bars.

(6) 60 deg. spirals recover from their diminished efficiency by the addition of necessary longitudinal bars, and 30 deg. spirals by the addition of rings.

(7) Among the pieces in Groups 5 to 8, where an equal steel ratio is adopted, the total action of spirals and longitudinal bars or rings in each type of reinforcement is not remarkably different, whilst those in Groups 6 and 8, where rings are employed, are a little greater than in others.

(8) Combination of longitudinal bars and rings cannot develop any material influence upon torsional resistance.

(9) The torsional resistance of the pieces in Group 10, where double 45 deg. spirals are embedded, is the greatest, although the steel ratio is less than in Groups 5 to 8.

(10) The torsional resistance of the pieces in Group 11, where longitudinal bars are added to the double spirals, is still higher than that in Group 10.

(11) The sole demerit in these pieces is that the inner spirals cannot be stressed as highly as the outer ones, the stress in steel varying in direct proportion to the distance from the axis.

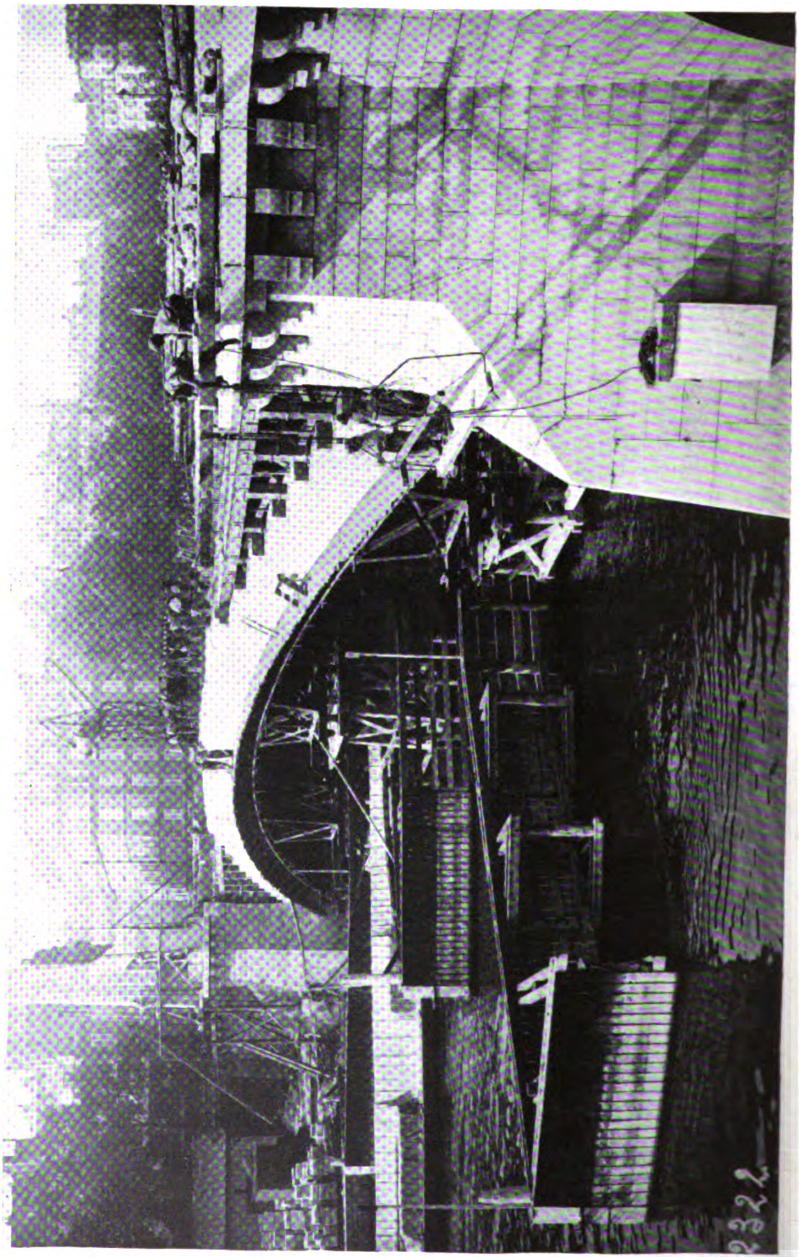
(12) At the maximum value of the torque, the resistance of concrete against tension, especially that of the core of a solid section, is not yet exhausted, and at the same time the reinforcement is not yet stressed up to its breaking point ; thus the twist is resisted partly by concrete and partly by steel.

(13) For members subjected to both compression and torsion, as in the case of reinforced concrete screw piles, such reinforcement as in Groups 5 or 7 is to be recommended in the first place.

(14) For members to be subjected to pure torsion, such reinforcement as in Groups 2, 10 and 11 should be recommended in the first place, and that in Groups 6 or 8 in the second.

Concrete House Competition.

PRIZES totalling £1,000 are offered by the Portland Cement Selling and Distributing Co., Ltd., for designs for two types of all-concrete house (one costing £1,750 and the other costing £750). The winning designs are to be erected at the next Ideal Home Exhibition at Olympia. Full particulars may be obtained from the Secretary, Concrete Houses Competition, 20 Buckingham Gate, London, S.W.1.



Pont de la Tournelle, Paris. (*See p.* 649.)

First Reinforced Concrete Bridge across the Seine in Paris.

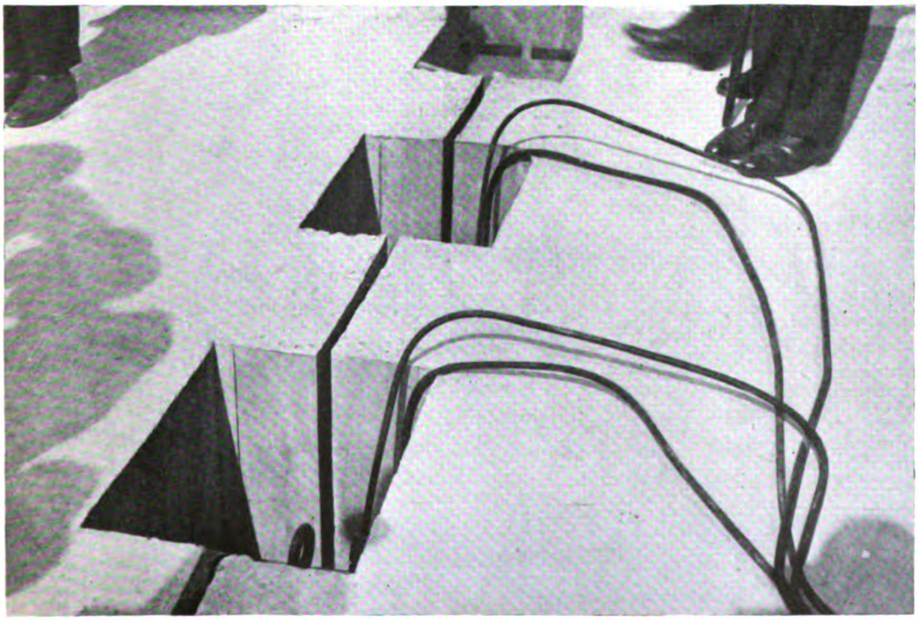
CONSTRUCTIONAL operations on the first reinforced concrete bridge to be built in Paris are expected to be completed this year. This bridge, known as the Pont de la Tournelle, takes the place of a bridge built in 1654, the numerous piers and short-span arches of which were not only a hindrance to navigation but were in some measure responsible for the frequent flooding of the city above the bridge due to the piers diminishing the discharge of water in time of flood.

The new bridge crosses the river in one span of 242 ft. between abutments each 82 ft. long. The arch and abutments are entirely in reinforced concrete.

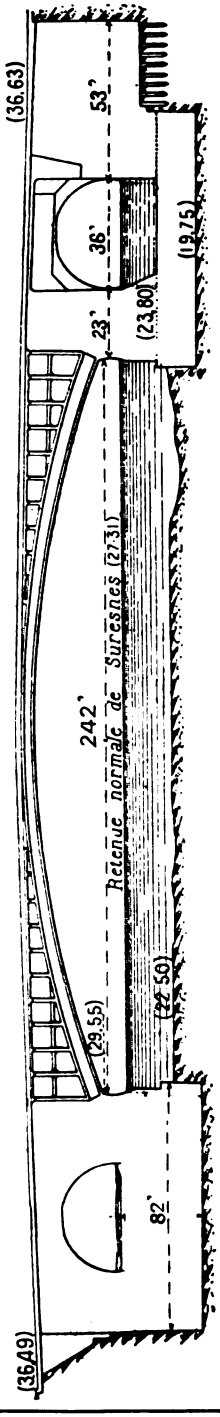
The river span consists of three ribs, each 21 ft. wide spaced 7 ft. 4 in. apart, on which the deck slab is carried by square columns.

A method of construction, devised by M. Freyssinet, and used by him in the construction of the Villeneuve-sur-Lot and St. Pierre de Vauvray bridges was used by the designers of this bridge, MM. Lang & Deval, Ingénieurs des Ponts et Chaussées. In this method each rib is cast in two half sections, and the shuttering for the first rib used for the other ribs. The usual method of lowering the forms below the arches is departed from, and the arches are lifted above the framework.

For this purpose each rib is constructed in two independent sections separated by a narrow space at the crown, and in this space are placed hydraulic jacks, acting horizontally, which slightly push apart the two half-arches. The horizontal pressure also slightly lifts the end of the ribs, thus raising them out of the formwork. The gap at the crown of the arch is filled with reinforced concrete slabs coated with grout, which act as keys to the arches when the pressure is released and the joint allowed to close.



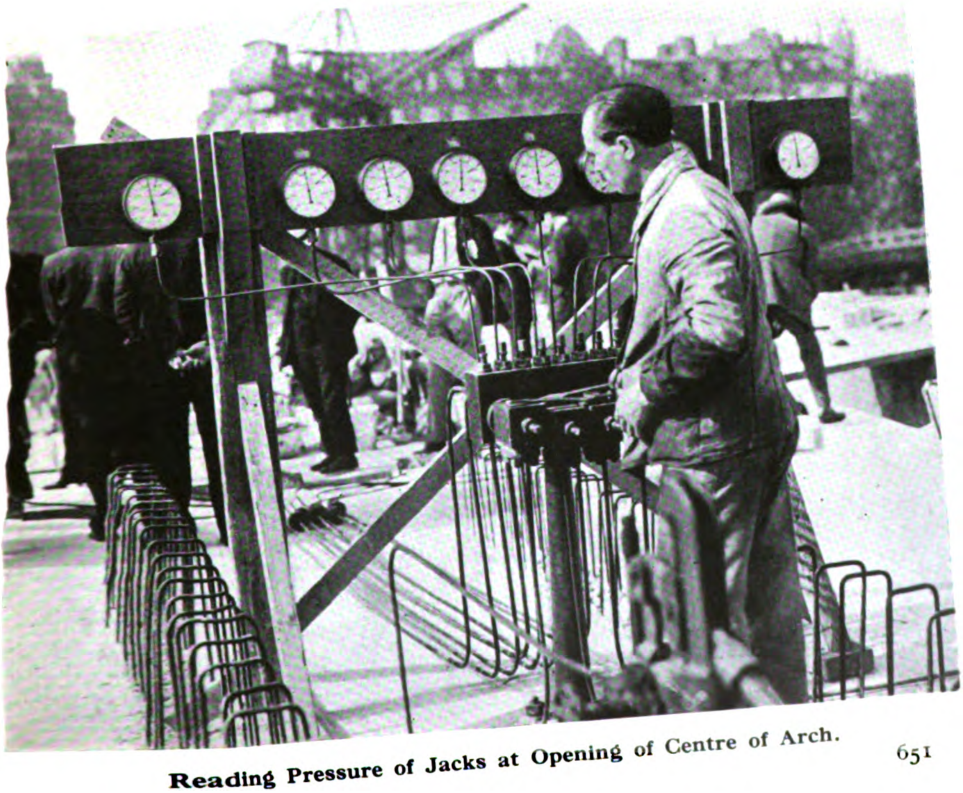
Openings for Jacks at Centre of Arch.



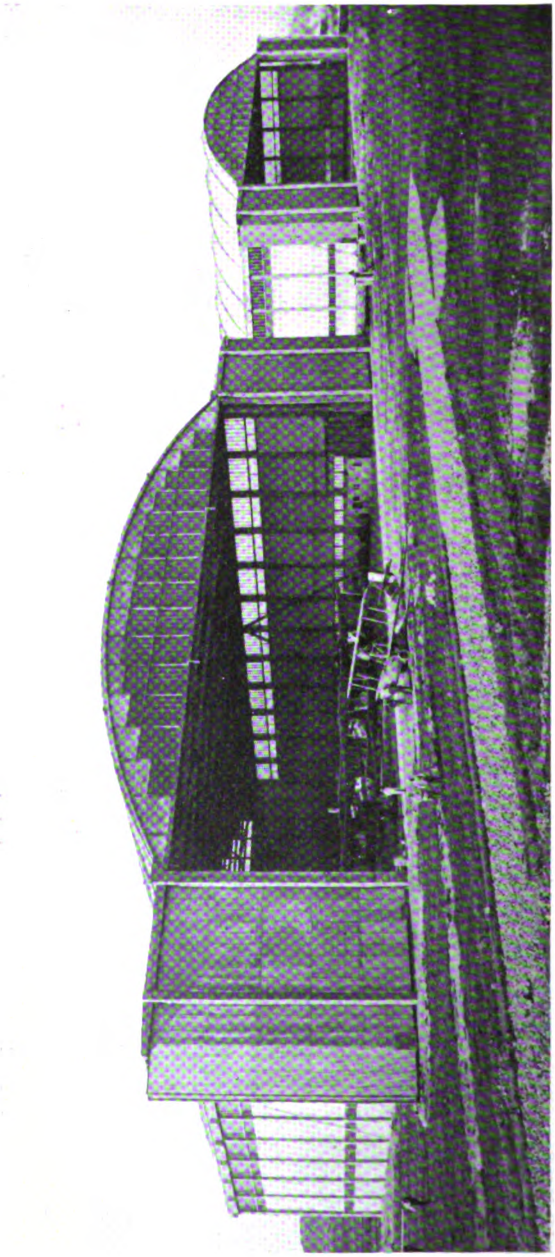
Pont de la Tournelle, Paris: Elevation.

In this process the pressure existing at the crown of the arch may be tested, as it is the force exerted by the jacks which separate the half-arches. In this case the pressure was 2,200 tons. Moreover, it may be ascertained whether the shape of the arch is according to the design. If the neutral axis is altered through the yielding of the formwork or other cause, it may be re-established according to the design by the hydraulic jacks.

This process was used in constructing the Veurdre Bridge, whose arches are of 238 ft. span. In this case the free space at the crown was not filled in with concrete, metal plates being introduced. The adoption of this device enabled the shape of the arch to be rectified two years after the bridge had been opened to traffic. Meanwhile contraction of the concrete had taken place, and this had produced a sag at the crown of about 4 or 5 in. Hydraulic jacks were reinserted and the two half-arches were separated again without interruption of traffic over the bridge. As the space between the half-arches was increased metal plates were introduced and levels taken, and when the level, according to design as previously established, had been reached, the lining between the two sections of the arch was completed and filled in with concrete. Since then, the shape of the arch has not changed. By this process alteration in the shape of an arch may be corrected during or after its construction. At the time of receiving these notes and photographs (the beginning of October) the first two arches of the Pont de la Tournelle had been successfully completed.



Reading Pressure of Jacks at Opening of Centre of Arch.



Aeroplane Sheds near Toulon. (*See p.* 653.)

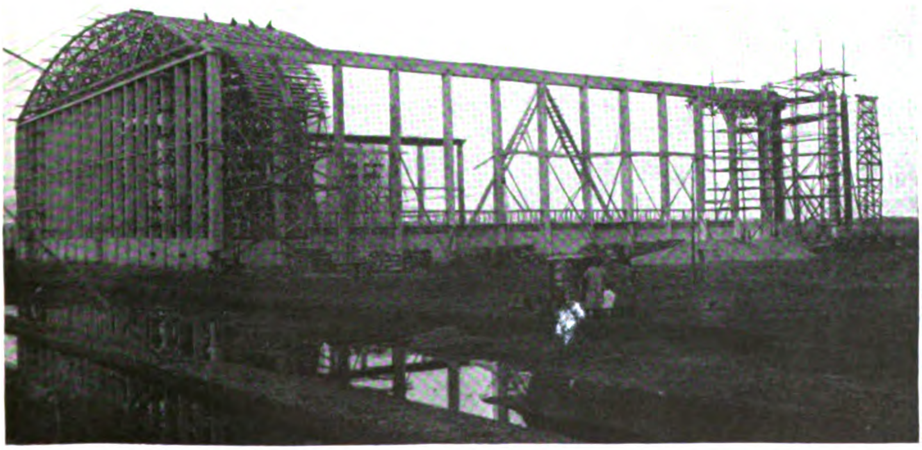
New Aeroplane Sheds near Toulon.

Two reinforced concrete sheds of considerable interest have just been completed at Polyvestre, the seaboard centre of aviation near Toulon. These sheds were required to provide an unobstructed floor area of 180 ft. wide and 197 ft. long, with a headroom of 49 ft. and doorway openings equal to the full width of the shed. The tender submitted by the Société d'Entreprises Limousin was accepted on a design prepared on the Freyssinet system.

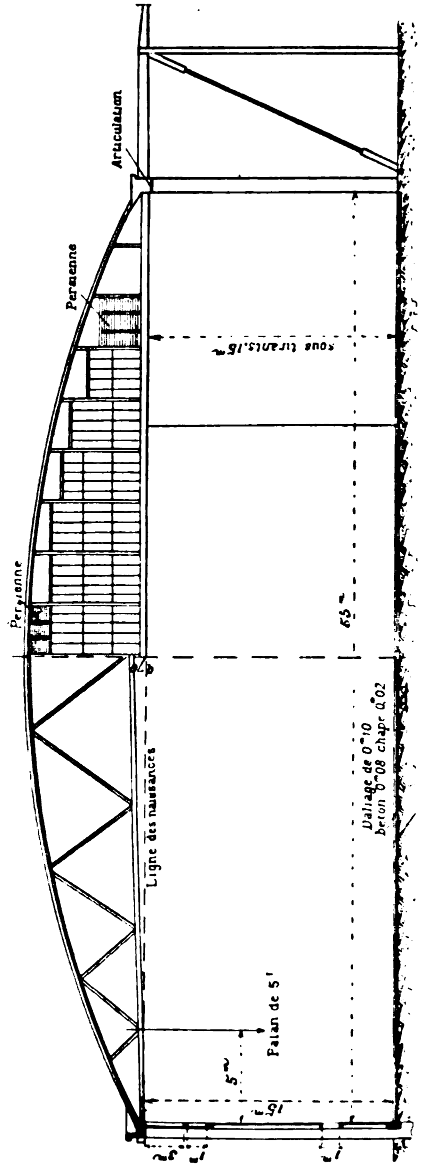
This design consists of a thin reinforced concrete vault supported by a number of arched lattice girders, also in reinforced concrete, spanning the full width of the shed. Generally the diagonal members of such girders work some in compression and some in tension, but in this case, owing to the large span of the girders, the compression members would have been very long, some 26 ft. to 30 ft., and consequently of large cross-section to resist buckling.

To obviate this disadvantage M. Freyssinet has provided a camber to the bottom tie of each arch and so arranged the method of construction that all the diagonal members are in tension and therefore of small cross-section, as may be seen in the accompanying photographs.

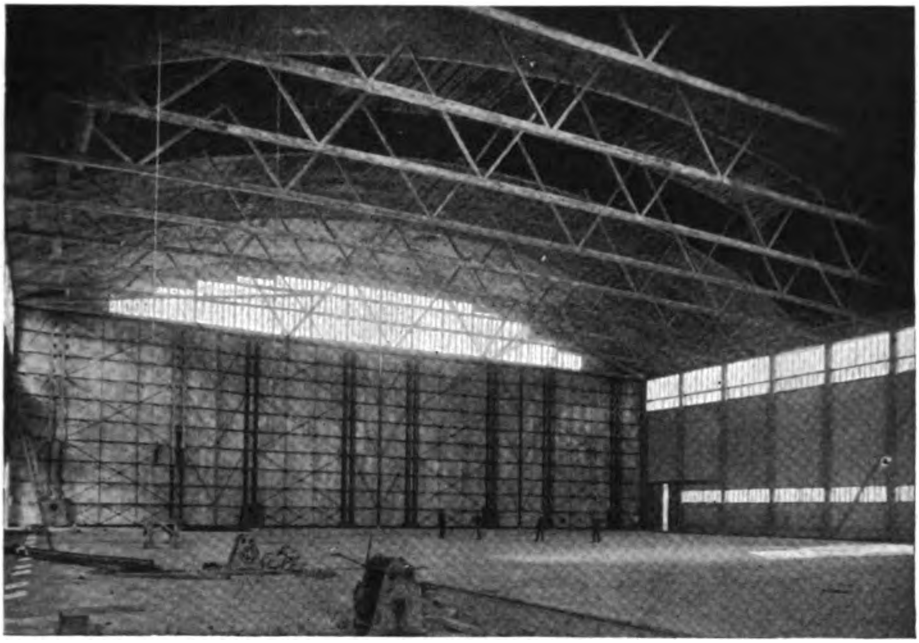
The tie-bars were arranged to be in single lengths and securely anchored into the springings of the arch, which is considered as being of the two hinged type. Actually the ties are in the shape of a link polygon, but to form them in the first instance to this shape would have required a rather complicated system of shuttering. In order to simplify the method of construction as much as possible the roof was constructed in panels, each panel being of such proportions as to be perfectly stable under its own weight, consisting of a portion of the



Aeroplane Sheds near Toulon.



Aeroplane Sheds near Toulon: Cross Section.



Interior View.

vault together with its supporting arch rib and tie rods, which were left unconcreted but supported in a horizontal position.

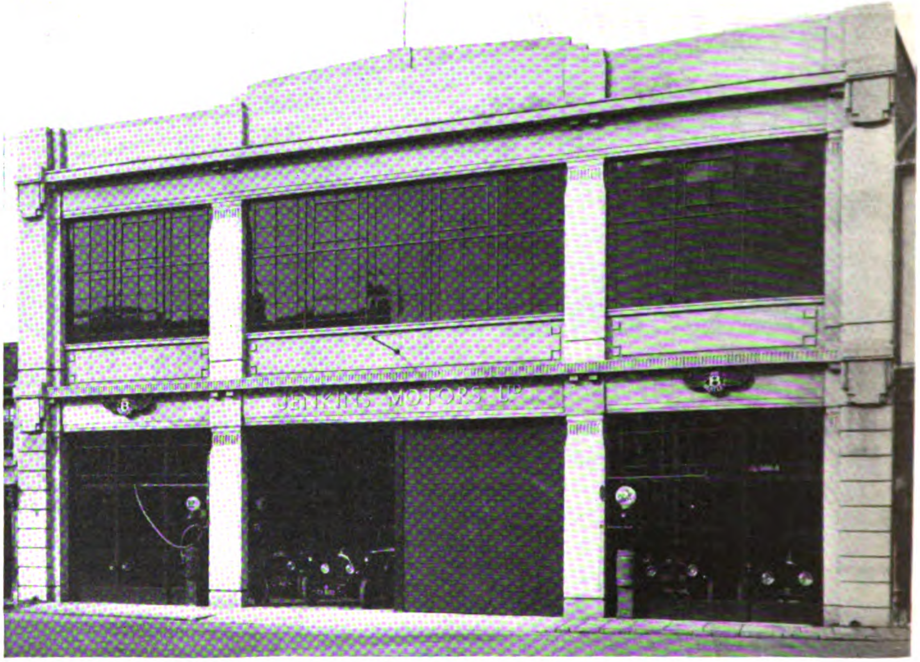
Jacks were then introduced under the ties at points where the diagonal members were required to intersect. The jacks being simultaneously operated the tie-bars were then raised at these points to their required elevations, thus forming the necessary camber. Naturally this operation increased the tensile stresses in the tie-rods and produced in the arch rib additional compressions and an elastic deformation in the opposite sense to that due to its own weight. These stresses and deflections had been allowed for in the design, which was prepared with a view to this method of construction.

Next the steel rods required in the diagonals were placed in position and anchored securely to the arch rib and tie-bars, this part of the work being completed with the concreting up of these members and finally the removal of the jacks. The tendency for the cambered tie to straighten out due to the thrust of the arches at the springings is calculated to be sufficient to put the diagonals in tension and to counterbalance completely all stresses due to compression. The concrete surrounding the tie-rods and diagonals thus serves merely to protect the steel from corrosion and to ensure good anchorage at the joints.

In carrying out the work the arches were given an initial camber of 2 in. in excess of the final rise required in the finished span when the centering was removed, the final camber to the ties at mid span being 27½ in. Under these conditions it was possible to construct the vault spanning between the panels of no more than 2⅜ in. in thickness, whilst the arch rib constituting the top member of each girder is only 16 in. thick.

Architectural Detail Cast in Shuttering.

In the construction of the reinforced concrete garage illustrated below an interesting departure was made in the method of forming the architectural features on the front elevation, the whole of which was cast by the main shuttering. rubbing down the whole of the front with carborundum was £11. The cost of adding natural or cast stone detail would undoubtedly have been far in excess of this sum.



Concrete Garage Front at Swansea : Architectural Detail Cast in Main Shuttering.

We are informed that the total cost of supplying the extra moulds and fixing them in the shuttering, planing, sizing and oiling the shutters, and using a slightly richer mix than usual, was only £32 14s. The cost of cleaning and

The garage is at Swansea. Messrs. Hubert Rogers & Ward, of Swansea, are the architects; the designers for the reinforced concrete, who were also responsible for devising the moulds and shuttering, are Messrs. A. G. Thompson and D. Manolopoulos, of Gower Chambers, Swansea.

High Strengths with Wet Mixes.

A series of tests has been carried out by the Building Dept. of the City of Detroit to determine the strength of very wet mixes as actually used for the laying of a large garage floor. The consistency of the concrete was such as to give a slump of 8 inches. The average strength of six specimens, mixed 1 : 2 : 4, was found to be 3,628 lbs. per sq. in. at 28 days in the case of Super-Cement and 1,989 lbs. per sq. in. in the case of ordinary American Portland cement.

Effect on Design of Plastic Yield and Shrinkage of Concrete.

THE Institution of Civil Engineers has considered it advisable to give a fuller abstract of the paper entitled "Plastic Yield, Shrinkage, and other Problems of Concrete and their Effect on Design," by Dr. Oscar Faber, O.B.E., D.Sc., M.Inst.C.E., which is to be brought forward for discussion at the Institution. This longer abstract is as follows :—

The author shows that :—

(1) Structures of reinforced concrete with stresses inside those allowed in good practice continue to deflect without change of load or temperature, a result due partly to shrinkage and partly to plastic yield.

(2) Consequently the absence of permanent set or deflection must not be insisted on as a necessary criterion of safety where the test involves an appreciable time-element.

(3) This yield and shrinkage produce a large though gradual redistribution of stress between the steel and the concrete in a reinforced concrete structure, of such a nature generally as to relieve the concrete and add to the steel stress. Compression steel in columns loaded at 4 weeks may, at the end of a year, be stressed to 21,500 lb. per sq. in. when the concrete is only stressed to 389 lb. per sq. in. (a result many times greater than figures as normally calculated), and if loaded earlier or left loaded longer the stress may reach higher values still, and may indeed reach the yield point.

(4) Present regulations, which take no account of these matters, leave much to be desired.

(5) The deflection of reinforced concrete beams, while only about six-tenths of the calculated deflection when the load is first applied, may amount to about six-tenths more than the calculated deflection after about 6 months, the final deflection then being about 2⅔ times the original and still increasing.

(6) When the load is removed, only the initial elastic deflection disappears, the deflection due to shrinkage and plastic yield remaining as a permanent set.

(7) Reinforced concrete structures when properly designed, are not dangerous by reason of these phenomena, but special care is necessary in binding compression steel, whether in beams or columns.

(8) The modulus of elasticity is much greater than that specified in most regulations, but yield and shrinkage in some cases produce results similar to those obtained with a very low modulus.

References are given to literature, mostly American, showing actual deformations on structures over long periods. Deformations at the end of a year or two amounted to five or six times the deformation when the load was first applied. Concrete slabs designed for 300 lb. per sq. ft. deflected ⅜ in. in 3 years, though standing without applied load.

The values of shrinkage in concrete given by various authorities are shown to agree in the main with the author's values, namely :—

1 week	0·00008
2 weeks	0·0002
3 ,, ...	0·00025
4 ,, ...	0·00029
12 ,, ...	0·0004
20 ,, ...	0·00045
52 ,, ...	0·0005

These figures may seem small, but they must be compared with deformations due to other causes :—

Shrinkage of concrete,
Strain in steel stressed to 15,000 lb. per sq. in.,
Expansion of steel or concrete due to 91° F. change of temperature
Strain in concrete having $E = 4{,}000{,}000$ lb. per sq. in., stressed to 2,000 lb. per sq. in.,
Strain in concrete having $E = 2{,}000{,}000$ lb. per sq. in., stressed to 1,000 lb. per sq. in.

In each of these cases the deformation is 0·0005.

Experiments.

Four test-beams were made of reinforced concrete 15 ft. by 5 in. by 2 in., reinforced in tension only, so loaded that beam no. 1 was stressed to 676 lb. per sq. in. in the concrete and 13,750 lb. per sq. in. in the steel, beam no. 4 to approximately 2½ times these stresses, and beams nos. 2 and 3 intermediately. The load was applied at the age of 4 weeks, and it was found that the deflection, instead of remaining constant, increased from 0·3 in. to 0·82 in. in beam no. 1, from 0·5 in. to 1·32 in. in beam no. 4 (and beams nos. 2 and 3 proportionately) in a period of about 30 weeks. The increase was comparatively rapid at first but slow after the age of 14 weeks.

It is shown that plastic yield and shrinkage afford necessary and sufficient explanation of the results. Shrinkage which would not produce deflection in a homogeneous beam will do so in beams in the special condition of reinforced concrete.

Extensometers were fixed to the top and bottom of the beams. The shortening of the top flange is shown to consist of :—

(1) Elastic strain proportional to the stress divided by a Young's modulus of 4,000,000 lb. per sq. in. (actually measured).

(2) Plastic yield proportional to the stress and amounting to approximately twice the elastic strain previously given.

(3) A shrinkage independent of stress, of which 0·0002 occurred between 4 and 36 weeks, and 0·00029 occurred between 0 and 4 weeks.

The total shortening of the top flange is about six times the shortening due to elastic stress in the case of beams stressed to 600 lb. per sq. in., a figure in good agreement with the American tests previously referred to.

Two further beams, nos. 5 and 6, containing compression steel were then studied. These are also analysed with the help of extensometers, and the stress on the compression steel in beam no. 6, which was 3,553 lb. per sq. in. on first loading, increased to 15,253 lb. per sq. in. in about 20 weeks, after shrinkage and yield had occurred, and it continued to increase. No buckling of the compression rods occurred, although no stirrups were used.

The phenomena studied transfer from the concrete to the compression steel a large part of the total compression, which relieves the concrete of stress and so reduces the plastic yield as compared with beams not reinforced in compression. Compression reinforcement, therefore, is useful.

Beam no. 4 was wetted at 30 weeks. This showed that the shrinkage which produced part of the deflection is chiefly irreversible, and only reversible to the slight extent that would follow from the alternate wetting and drying of an inert material such as porous brick.

The point load was removed from beam no. 3 at the age of 30 weeks, and the reduction in deflection corresponded to that produced by the elastic strain only, the larger components due to shrinkage and plastic yield remaining as a permanent set.

Tests were made on shrinkage of mortars. Rapid hardening cement shrinks more than twice as rapidly as ordinary cement in the early stages, but at the age of 28 days the total shrinkage is substantially the same. This confirms the author's view that the shrinkage is due chiefly to the irreversible changes accompanying hardening and only slightly to drying out reversibly.

Application of the author's formulas, which allow for shrinkage and plastic yield, to a concrete column 10 in. square with 1 per cent. of steel, loaded with 60,000 lb., gives the following results :—

STRESSES : LB. PER SQ. IN.

Age.	Load.	Due to Shrinkage.		Due to Load.		Total Stresses.	
		Concrete.	Steel.	Concrete.	Steel.	Concrete.	Steel.
Weeks.	Lb.						
(*a*) 4	0	– 67½	6,750	0	0	– 67½	6,750
(*b*) 4	60,000	– 67½	6,750	(elastic) 564	(elastic) 4,230	496	10,980
(*c*) 52	60,000	– 104	10,400	493	11,100	389	21,500

(– denotes tension.)

The following table is a comparison with stresses as ordinarily calculated :—

STRESSES : LB. PER SQ. IN.

	Stresses by Author's Formulas.		As Ordinarily Calculated.			
			$m = 15$		$m = 7{\cdot}5$	
	Concrete.	Steel.	Concrete.	Steel.	Concrete.	Steel.
(*a*)	−67	6,750	0	0	0	0
(*b*)	496	10,980	525	7,900	564	4,230
(*c*)	389	21,500	525	7,900	564	4,230

If the load is applied earlier and left longer, the steel stress may, in about 12 years, reach 29,150 lb. per sq. in. or even more, and the stress may eventually reach the yield point under certain conditions.

These figures are entirely consistent with actual measurements on American buildings previously referred to.

Beams Reinforced in Tension only.—The shrinkage of beams, of which the ends can move without restraint, has little effect on stress, as the unequal shortening of the top and bottom can relieve itself by deflection. Plastic yield, however, virtually increases the modular ratio from *m* to *mk* where *k* is the "plasticity factor." Taking the latter between 4 and 52 weeks as 3, the effect is as if *m* were increased from 7½ to 22½. This has the effect of lowering the neutral axis, reducing the concrete stress by approximately 30 per cent., and increasing the steel stress by about 7 per cent.

Beams with Compression Reinforcement.—These can be treated as regards the compression reinforcement very much as concrete columns. Shrinkage and plastic yield produce a high stress on the steel (it may be many times the value normally calculated) and correspondingly relieve the concrete.

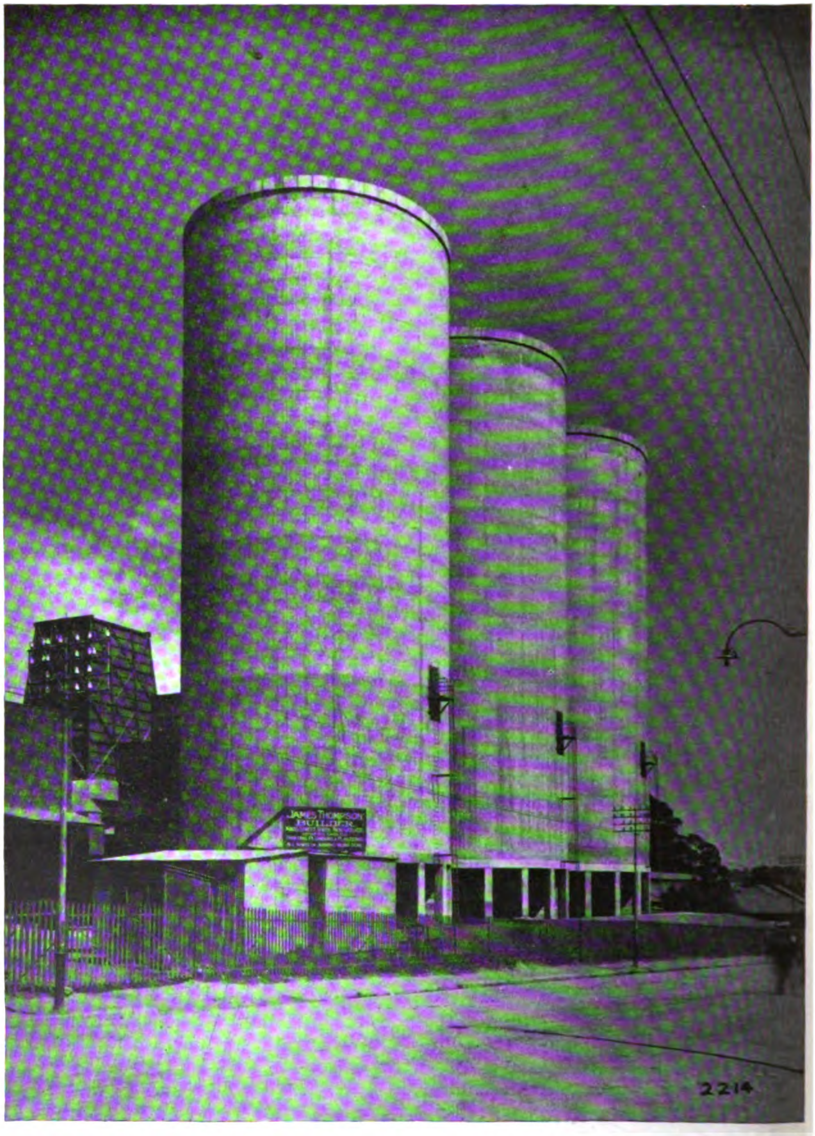
Young's Modulus for Concrete.—It is shown that this needs further definition. Taking it as the average slope of the stress-strain curve with so short a time under stress that no appreciable part of the shrinkage or plastic yield is measured, it has a value of about 4,000,000 lb. per sq. in. for the concrete used in the tests. In general, Young's modulus is found to vary directly with the cube strength of the concrete according to the formula E = cube strength × 1,000. If, however, the strength of concrete is measured on cylinders having a height equal to twice the diameter, a lower figure is obtained, so that approximately E = cylinder strength × 1,430.

Stones and timber also are subject to shrinkage and plastic yield.

The Setting and Hardening of Cement.—The colloidal conception of the constitution of concrete and the known properties of inorganic colloids adequately account for all the observed properties in connection with the shrinkage, hardening, and plastic yielding of concrete.

The Safety of Reinforced Concrete.—Apart from the high compressive stress in longitudinal compression steel, which calls for greater care in the provision against buckling, there is no reason to suppose that reinforced-concrete structures are less safe than has hitherto been supposed. Nevertheless the ultimate deflections must be expected to be much greater than those indicated by short-time tests and will increase over long periods.

Conclusion.—The analyses given are in general terms, but in the examples definite values of the plasticity factor have been adopted, based on the tests. The author recognises that more research on these values is desirable.



Reinforced Concrete Cooling Towers at Johannesburg. *(See p. 661.)*

Reinforced Concrete Cooling Towers at Johannesburg.

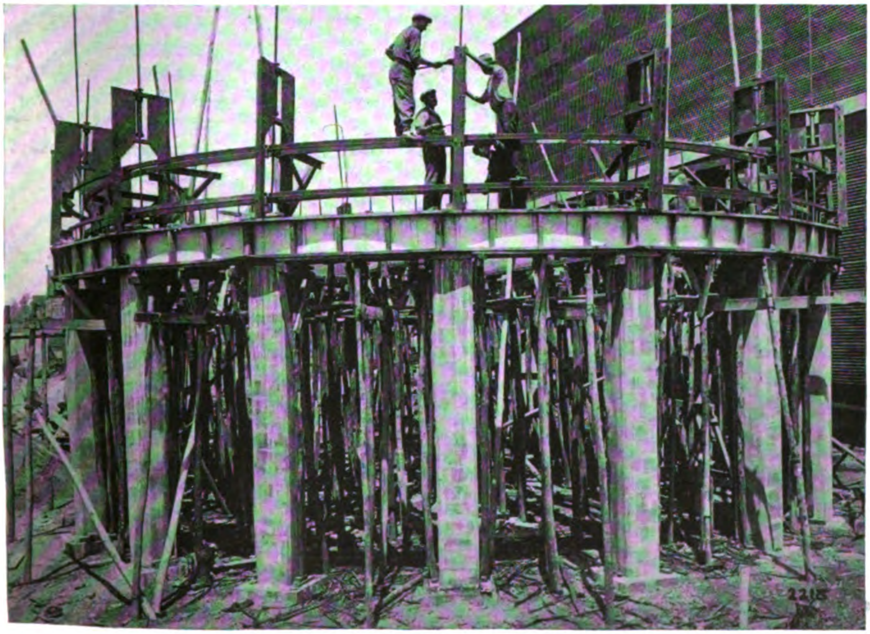
THE battery of cooling towers illustrated has recently been constructed at the Municipal Electric Power Station, Johannesburg. They are erected on a foundation of clay forming part of an old river bed, and at the time of their construction were believed to be the largest single structures of their kind.

The three towers have a total height of 125 ft. and a diameter of 45 ft., supported on columns and standing in a cooling pond 175 ft. long by 53 ft. wide, with an average depth of 3 to 4 ft. The cylindrical portion is 110 ft. in height and supported upon 18 columns. Each column is 16 ft. high and 20 in. square, and they are tied together at the top (immediately below the cylindrical portions of the towers) by a circular beam having a depth of 20 in. and a width of 15 in. This serves to tie the supporting columns and carries the meshwork of beams supporting the filling and forms the springing point for the walls of the tower proper. These walls, which are 7 in. thick, are not braced in any way. They are heavily reinforced with indented steel bars and are designed to be self-supporting.

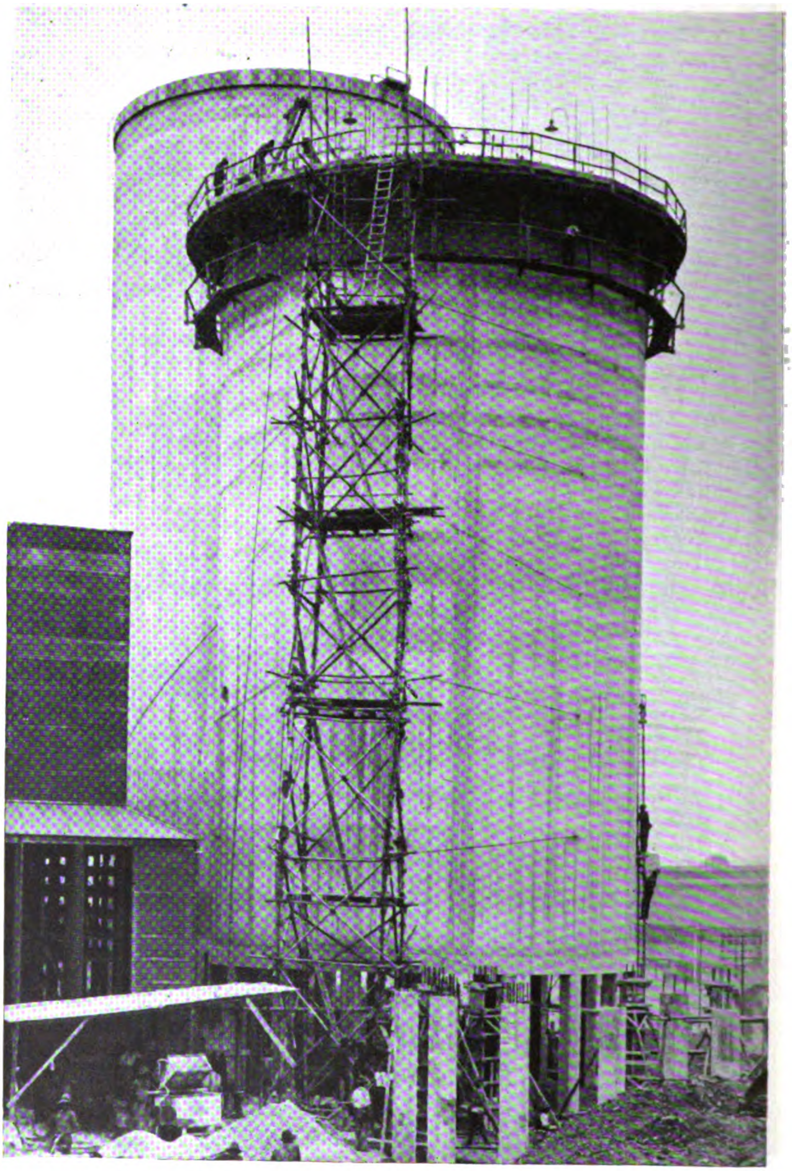
The main load of the towers, and the bending moment induced by wind pressure, are taken care of and supported by the 18 columns upon the outer periphery. The centre hexagonal column serves to support the timber filling which breaks up the water, and is supported by a single pyramidal foundation unconnected with the main foundation.

The foundations which form the main bases of support of the columns carrying the inner tower proper, are in the form of a hollow ring, 12 in. thick, from which rise pyramidal bases to each of the exterior columns. This forms, in fact, a continuous beam of a ring shape and has been designed to give a load to the ground of 4,000 lbs. per square foot.

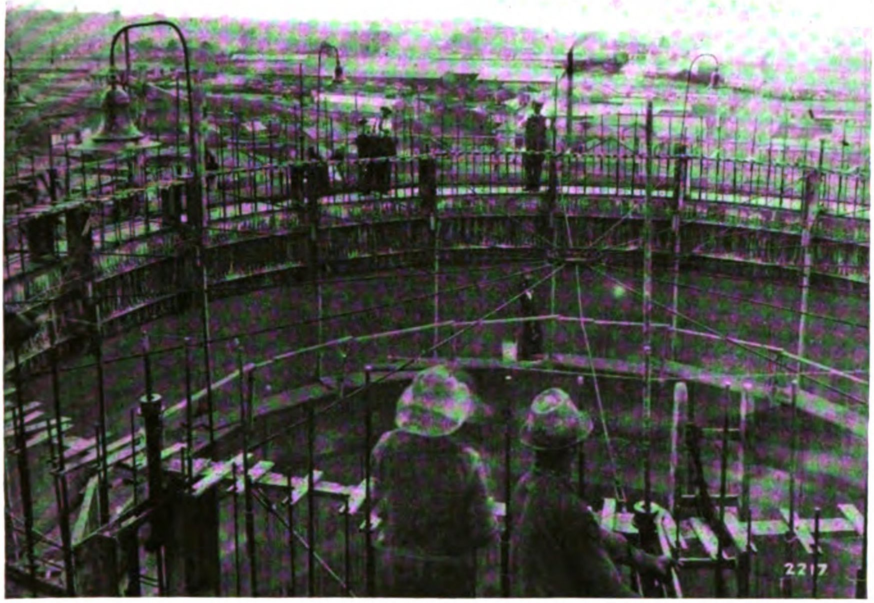
The whole of the reinforced concrete work was mixed in machine mixers in



Work at level of Circular Beam, showing " U " frames for Lifting Centering being fixed in position.



Second Tower during Construction.

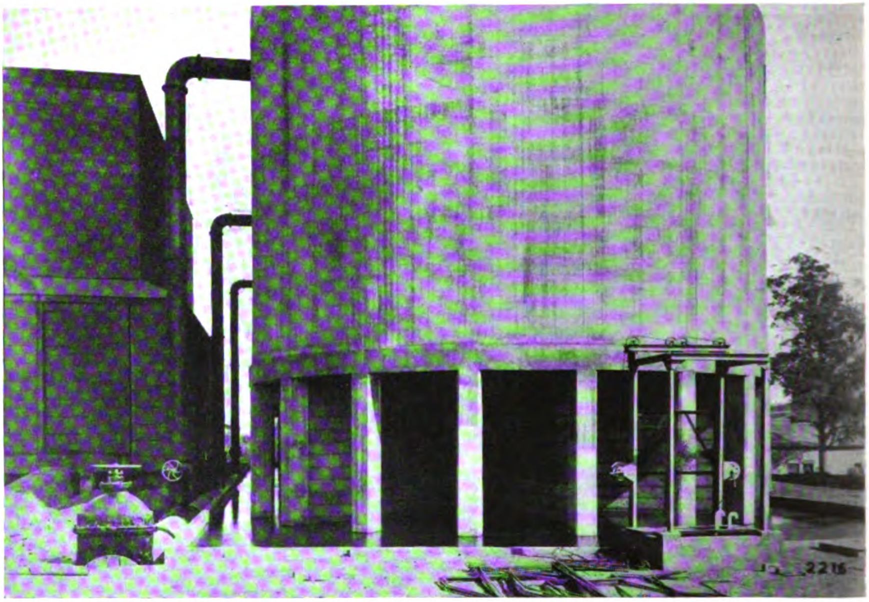


Nearing the Top of one of the Towers, showing arrangement of moving forms.

the proportion of 4 parts ¾-in. stone to 2 parts sand and 1 part Portland cement. The towers were constructed singly. When the work had reached the level of the circular beam connecting the tops of the columns, the jacks for the lifting centering were assembled. These were constructed of steel plates and angles in the form of a **U** frame, which held a heavy hollow screw 2¾ in. in diameter capable of being raised or lowered and fitted with a hexagonal nut. A steel bar of 1⅛-in. diameter was placed through the hollow screw and clamped underneath the screw-bottom by means of clamps and set screws. The nut on the jack-screw was held underneath the top member of the frame so that when the screw was rotated the frame was lifted up, the steel bars forming the support during the period when the concrete was wet. Eighteen jacks were used, one over each column. They were connected to each other by angle-iron chords bolted to the **U** frames. These chords held the centering, which consisted of strips of jarrah timber approximately 2¾ in. wide and 4 ft. long. To serve as a gangway a walk of timber was supported on the jack frames by means of angle-iron brackets projecting from the frames and bolted to them.

When the jacks had been erected and trued, the work of concreting the cylinder portion of the tower commenced, and was carried on during all weathers and throughout the 24 hours. The 24 hours were split into three periods of 8 hours each and in each 8-hour shift one gang was employed on the concreting only, working round the circle and followed by another gang screwing up the jacks. The work was kept continuous so that fresh concrete was always being placed while the centering was continually moving upwards.

Readings of the maximum and minimum shade temperatures were kept throughout the work, and it was found that the highest shade temperature experienced was 87 degrees while the lowest temperature was 29 degrees. Several heavy thunderstorms accompanied by severe electrical disturbance occurred during the progress of the work, but on no occasion did the work cease, and it is interesting to know that although the foundation soil consisted of yellow clay



Base of Tower.

no cracks have occurred in the columns, towers, or tanks during the three years since the towers were constructed.

The warm water from the condensers is led into the towers by means of steel piping at a level approximately 42 ft. above the tank bottom where it is distributed into timber troughs over the whole inside area. These troughs spray the water over diamond-shaped strips of wood which still further break up the drops of water. The descending water meets the incoming air induced by the draught of the towers, and it is cooled and falls into the tank from whence it circulates back to the condensers. In order to prevent back-draught and to take advantage of whatever direction the wind is blowing from, concrete baffle walls—six in number—were constructed spanning between the exterior ring of columns and the centre hexagonal column. These baffle walls consist of pre-cast concrete slabs fitted and grouted into position in chases formed in the columns. The total weight of each tower, with the filling, is approximately 900 tons and the wind pressure on each tower, which was taken as 30 lbs. per square foot of surface, is 78 tons in all.

With the exception of the reinforcement, which consisted of indented steel bars, the whole of the material used in the construction of the towers was manufactured in Africa. The designs were prepared in Johannesburg by the Concrete Engineering Co. (South Africa), Ltd., under the consulting engineers, Mr. G. M. Clark and Partner, and the work was carried out by a Johannesburg builder, Mr. James Thompson. We are indebted for these particulars to the Indented Bar and Concrete Engineering Co., Ltd., of London.

Reinforced Concrete Transmission Poles.

It was announced last month that it had been decided to use steel poles or towers, for carrying the high-tension electrical distribution lines in connection with the Scottish scheme of the Central Electricity Board. The Board is preparing schemes to cover the whole of Great Britain, but so far only the Scottish and South East England schemes have been published. These schemes will entail the erection of hundreds of thousands of transmission poles, for it has been decided that distribution is to be by overhead lines.

We understand that this decision to use steel towers so far applies to the Scottish scheme only, and only to the high-tension transmission lines. These high-tension transmission lines in the Scottish scheme have a total length of about 220 miles, but the local distribution at low-tension will certainly account for a much greater mileage for which we understand the type of pole has not yet been decided upon.

There would thus seem to be an opportunity for the extensive installation of reforced concrete transmission poles in this country, which has always been far behind Continental and certain other foreign countries in the use of reinforced concrete transmission poles or towers.

For the schemes of the Central Electricity Board, the poles would vary in height from 35 ft. to 62 ft. according to the span, which varies from 500 ft. for 35-ft. poles, 700 ft. for 42-ft. poles, 900 ft. for 57-ft. poles, to 1,100 ft. for 62-ft. poles, for high-tension transmission. For low-tension transmission the poles would be 30 ft. high for 300-ft. spans and 35 ft. high for 400-ft. spans. The pressure of the foundation should not exceed 30 lbs. per square inch. For the longer spans double poles with the conductors carried on a connecting beam at the top would probably be necessary, owing to the great weight of a single pole 60 ft. in height of sufficient strength to carry the loads.

In a recent number of the "Electrical Review," Mr. Theodore Rich says:

"It is somewhat strange that in Great Britain, a country practically devoid of timber suitable for use as telegraph and power line poles, wood poles should be the rule; and that in France, Germany, and to a lesser extent in Austria and Switzerland, where forests abound, so many reinforced concrete poles are to be seen. Apart from a certain number of signal poles which are to be found on our railways, the use of reinforced concrete for such purposes is practically unknown with us, whereas on the Continent, but apparently not in America, such construction has made great strides for power line work. In addition to its general neatness, reinforced concrete, when well made, has the advantage of being permanent, whereas wood is subject to continual depreciation, and steel supports, whether sectional, tubular, or of lattice work, require periodical painting.

"About the first to construct reinforced concrete poles was M. Delamarche, of Grenoble, who in 1901 erected a line between two cement works in which he was interested, and from that time onwards the use of concrete poles has expanded in France, other countries following suit. The sections used are very varied: (*a*) Hexagon with a circular hollow, vertically; (*b*) oblong box shape; and (*c*) rectangular, with horizontal cylindrical openings. These three types were developed by M. Delamarche. A pole of the type (*c*) is fitted with a

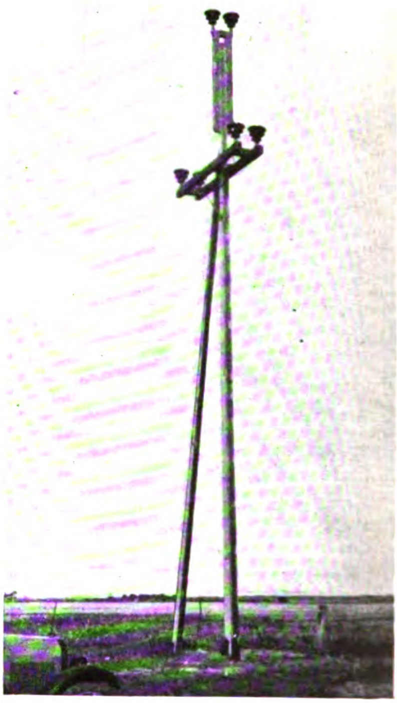
Concrete Power-Transmission Pole.

transmission line on the right side and distribution wires on the left. The designs of this engineer are now used by the "Conduites et Potaux" Company, of Grenoble. The brackets are double in this case, being gripped with bolts on each side. Other types are of a plain H section, an H section lightened with windows, a bulb rail section with ribs forming honeycomb, a square section hollowed out with windows, and a section made with four rectangular corner posts braced with horizontals.

"In Italy, Sweden and Germany centrifugal-cast poles have a considerable popularity. In France, before the war, reinforced concrete posts were usually made to the specification then customary for building work; they were, as a rule, heavy, and were used primarily for comparatively heavy trunk lines at 15,000 to 45,000 volts. Owing to their weight they were hardly suitable for rural h.p. distribution lines where first cost was an important consideration. Some of those who were in France between 1914 and 1919 may remember the heavy ferro-concrete poles stretching towards Doullens and Amiens from Arras, shattered in many cases by shell fire, and the commencement of a line from Abbeville towards Tréport. In the south and east of France considerable developments took place during the war in the use of concrete, especially for main transmission lines in the Grenoble area. The height varied up to about 48 ft.

"Since the war there has been continuous progress regarding the use of concrete for semi-distribution and distribution lines, and supports of various types can be seen in almost all parts of the country. As a rule, when there is a contract for so many miles of concrete poles, space is hired at some convenient point where ballast is obtainable; the poles are made on the ground in the open air and carried to their destination by lorries and trailers. After the war a demand for power sprang up all over the country, and a number of rural lines were rushed up with untreated forest poles, some of which have deteriorated with great rapidity.

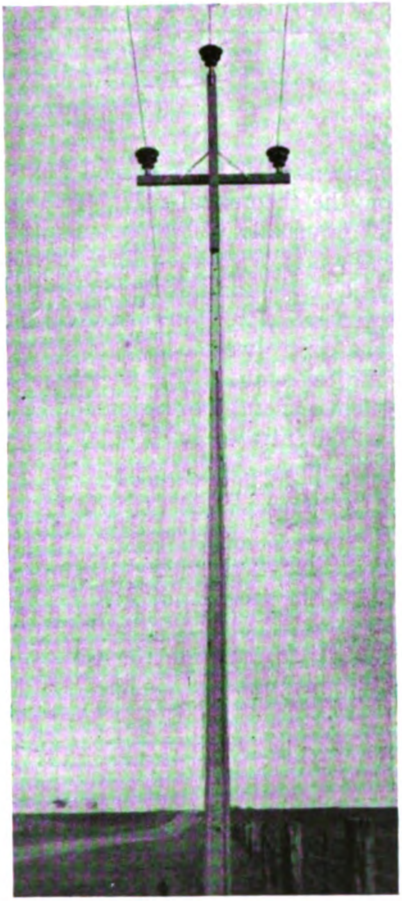
"A demand has sprung up for concrete poles which are lighter in weight and therefore more handy for erection than earlier types, which can compete in first cost with good-class wood poles; these have the added advantage of permanency, and therefore can be used for general rural h.p. distribution work. To meet this demand a type of pole, known as the 'Sanca,' has been developed; it is made by the Société des Applications Nouvelles du Ciment Armé, of Paris. It is made of high-tensile cement, the reinforcement being of high-tensile steel, so that the weight is cut down, while to aid transport, a matter of special importance where poles have to be man-handled for cross-country lines, it is made in two parts.



66,000-volt Steel-and-Concrete Angle Pole.

"Up to recently a number of attempts have been made to construct a satisfactory sectional reinforced concrete pole, but without technical or commercial success. M. Allard, engineer of the above company, got over the difficulty in a simple manner: the pole is made in two parts, the section of it being that of an H. The two halves are joined by means of two heavy galvanised fishplates placed flat against the flanges. Bushes are let into the concrete and cast to gauge; with the aid of six fitting bolts passing through the fishplates, three above and three below, a joint is made between the two halves. The result is that we get a pole which in the ordinary way is cast indoors on factory lines by labour accustomed to the job. The two lengths can be shipped in ordinary Continental railway trucks, not troublesome timber trucks, and they can be unloaded into a lorry without a crane and man-handled across a field, if required, without difficulty. Taking, for example, a pole (32 ft. 9 in.) long, for a normal cross loading of 400 lb., the upper part weighs about 4 cwt. and the lower about 5 cwt. In the case of a pole 36 ft. long for the same loading, the upper part weighs about 4½ cwt., the lower part being about 6¾ cwt. A connection is made to the armouring below for an earth plate, if desired, and the connection is continued by the steel fishplate. The bolt holes for the insulator brackets are bushed, and these are connected up in turn to the armouring. Two poles can be bolted together to form a stiff arrangement for angles; they are also used to form 'A' poles. When not too heavy, an ingenious arrangement can be used for erection. The butt of the lower section, with the fishplates bolted on, is dropped into the hole, which is stepped, the top sloping sideways; the lower end is lifted up and the top bolt pushed through the fishplates and pole. Using the top of the post as a prop, and pushing forward, the lower part is brought to a vertical position and then rammed. In the ordinary way a special spar is provided, fixed by a sort of clip, but in the absence of the special appliance, a temporary spar may be tied on to the base of the upper part, and by means of a rope the upper part is pulled round with the top bolt through the fishplates as a hinge. When it is vertical, a man shins up the pole and drives in the remaining two bolts and tightens up. A small gap remains between the upper and lower parts; to make the connection absolutely rigid, two short iron wedges are driven into the little gap, and a touch of cement finishes the job.

"Concrete posts have been tried out abroad for a number of years; their use has grown so much that a standard specification has been drawn up by the French Union of Electrical Associations. Owing to our climatic conditions, there must be many openings for their use at home."



66,000-volt Steel-and-Concrete Line Pole.

Deflection of Girders under a Series of Concentrated Loads.

By Dr. G. S. COLEMAN, D.Sc., A.M.Inst.C.E.

THE deflection of girders under a series of concentrated loads is usually a matter of considerable labour and consequent possibility of numerical error, but by the use of Clerk Maxwell's Law of Reciprocal Deflection such labour can be materially reduced.

Thus, let the uniform beam *ACB*, shown in *Fig.* 1, be subjected to a number of concentrated loads placed anywhere on the span. It is often desirable to know the theoretical value of the deflection at the mid-span, since the central point is usually where the maximum deflection will occur.

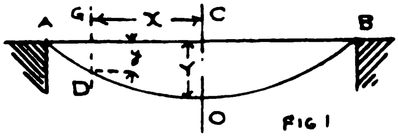


FIG 1

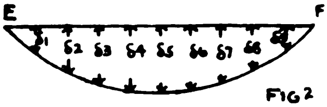


FIG 2

By Maxwell's law referred to above the deflection at *C*, due to a load at any point *G*, is the same as the deflection at *G* due to the same load at *C*. By utilising the general expression for the deflection at any point due to a concentrated load at the centre we are able to draw an influence line diagram for the deflection at the midspan.

The general expression for the deflection at any point along the span due to a concentrated load *W* at the centre is proved in any advanced text-book to be :—

$$y = \frac{Wl^3}{48\varepsilon I} - \frac{W}{2\varepsilon I}\left(\frac{lx^2}{4} - \frac{x^3}{6}\right)$$

it being noted that the values of x are measured from the midspan as origin.

Let the span be divided into ten equal parts as shown in *Fig.* 2 ; then, by taking x as successively equal to $0{\cdot}1l$, $0{\cdot}2l$, etc., we obtain Table I. It is only necessary to calculate the values for half the span as the deflection figure will be symmetrical.

TABLE I.

$x = l \times$:—	$y = \frac{Wl^3}{\varepsilon_1} \times$:—
0	0·0208
0·1	0·0197
0·2	0·0165
0·3	0·0118
0·4	0·0062
0·5	0

If the values of W and l be each taken as unity we shall be able to draw at once an influence line diagram for the deflection at C.

This is done by making δ_1 equal to 0·0062, δ_2 equal to 0·0118 and so on.

If, therefore, it is desired to find the value of Y due to loads $W_1 W_2$ and W_3 placed at 0·1l, 0·3l, and 0·8l from the left-hand abutment, we have at once :—

$$Y = \frac{l^3}{\varepsilon I}\{W_1\delta_1 + W_2\delta_3 + W_3\delta_8\}$$

the influence deflection curve being quickly drawn for any chosen span.

Questions and Answers relating to Reinforced Concrete.

***Readers are cordially invited to send in questions relating to concrete. These questions will be replied to by an expert, and, as far as possible, answered at once direct and subsequently published where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—*Ed.**

Joints in Concrete.

Question.—I have a query in relation to the usual specification clause to the effect that concrete must be stopped off by ramming against a board. In a bridge work contract where this stipulation was made, the contractors and clerk of works definitely stated that they have never been required to do so in longitudinal joints with steel passed through. I have, of course, seen longitudinal " bulkheads " cut and used, and realise it is not simple to get a true straight line ; but these were not cases where the contractors claimed special experience. Is not this the invariable practice, or is it possible to waive this clause and still obtain a sound job and smooth soffit ? What is the general practice, if not as specified ; and a reasonable expectation from workmen as to the amount of steel around which boards can be fitted where bars protrude ? Is it satisfactory to employ a very dry mix without ramming against a board face, and join later in the usual way with no further precaution ?

Robert Murray.

Warwick.

Answer.—We take it that this query relates to a clause sometimes met in specifications, to the effect that the concrete, instead of being allowed to be left to form its natural slope, must be finished to a vertical face wherever it is necessary to make a break in concreting. The necessity or otherwise of this clause would depend on the stresses in the structure. In a beam, for example, a plane of weakness at approximately 45 deg. might coincide with the plane of maximum tension due to shear, and so be highly undesirable. This is entirely a matter for the engineer to decide. If he has asked for this clause to be worked to there is probably a good reason for it. In general, it would not be satisfactory to employ a very dry mix without ramming against a board face with no further precaution.

O. F.

Sawdust Aggregate.

Question.—In an article by Dr. Oscar Faber in your issue for January, 1926, mention is made of concrete made with sawdust as aggregate in a mineralised or chemically treated form. Being anxious to find a better material than coke breeze for fixing joinery, etc., in buildings I would be indebted to you for information on chemically treating the sawdust.

A. Duncan.

District Engineer's Office,
Wellington, N.Z.

Answer.—We are afraid we cannot give you any information on the nature of the chemical treatment of sawdust to make it suitable as an aggregate for concrete. The process is a patented one, and has not been divulged. The chemical treatment renders sawdust fire-resisting, and also eliminates the expansion and contraction that would occur in untreated sawdust when mixed with water, with consequent cracking.

Book Reviews.

"Civil Engineering Specifications and Quantities" By G. S. Coleman and G. M. Flood.

OUR attention has been called to the fact that in a review of this book in our issue for August last certain words were printed in quotation marks whereas they were our reviewer's summary of paragraphs from the book and therefore should not have been in quotation marks.

The two paragraphs in question appear in the book as follows:—

> " *Sand.*—Sand for concrete and mortar is specified to be clean, sharp, river or pit sand, free from loam, clay, or any organic matter. No separate test for the sand, apart from its admixture with cement or lime, is generally stated, and the definition of sharp sand is somewhat hazy. Sand under this definition is supposed to act as a binder of the cement to the aggregate in the case of concrete, and if so should be composed of angular particles which are rough to the touch. For this reason pit sand is often specified, as the material has then been deposited at some prehistoric period at the bottom of a sea, and the particles have not been rolled over or ground against each other so as to become rounded and to have lost their binding power. In the case of river sand such rounding is probable, and many engineers would therefore bar its use, although it might otherwise be quite clean. Where river sand is allowed, care should be taken by the engineer that it is not obtained from a part of the river affected by the sea."
>
> " As the term 'sand' is often nowadays applied to crushed rock, it will be necessary, if such material is permitted, to specify the size of the particles. Many quarries will now supply it from the size of dust upwards. A useful size is from ⅛ to ¼ in., preferably smaller, and hence the sand should all pass a sieve of ⅛-in. square holes."

Our reviewer's comments on these two paragraphs were as follows:

> Among these may be mentioned the following quoted statements by the authors:
>
> (1) " Sand must be sharp," a requirement which is absolutely unnecessary.
>
> (2) " A useful size [for sand] is from ⅛-in. to ¼-in., preferably smaller, and hence the sand should all pass a sieve of ⅛-in. square holes." One would like to know how ¼-in. grains can pass an ⅛-in. sieve.

It will be seen that the words put in quotation marks by our reviewer were not in fact direct quotations from the book, and we apologise for any misunderstanding that may have arisen due to this error.

"Ratgeber für Bauführer und Poliere im Eisenbetonbau," by Dr. Ing. R. Hoffmann.

Berlin: Wilhelm Ernst & Sohn. Price R.M. 3.40

THIS little book is a revision by E. Klett of Dr. Hoffmann's "Foreman's Guide to Reinforced Concrete," of which the first edition was sold out in nine months. It is on somewhat similar lines to Mr. Lakeman's "Elementary Guide to Reinforced Concrete," published by Concrete Publications, Ltd. (of which 3.500 copies have been sold in two years).

This book is up-to-date in every way. The first chapter deals with the action of reinforced concrete structures and the behaviour of concrete under the effects of frost, chemicals, electricity, etc. A description follows of the various cements at present in use, and a list of the results to be expected from tests of both cements and concretes. Chapter 3 is devoted to formwork and scaffolding, and includes several excellent illustrations of timber formwork for beam and slab work, bridges, and arches. The chapter on steel bending and fixing gives examples of the latest types of bending and hooping machines.

Concrete mixes and strengths are dealt with from the point of view of sieve analysis and water content. Particular attention is given to the lay-out of the construction plant and the order of concreting the various portions of an arch ring.

In the final chapter there are illustrations showing how defective steelplacing may result in failures. The book contains 62 illustrations and graphs.—W.S.G.

Loadings and Pressures for Designing Purposes.

The following data has been specially compiled for this journal by Mr. Leslie Turner, B.Sc., A.M.Inst.C.E., and may be used as a general guide for designing purposes.

Floor Loads.

Superimposed or Live Loads, excluding the Dead Weight of the Floor.

Description or Purpose.	Equivalent Dead Load in lbs. per sq. ft.
Domestic buildings and private houses	70
Hospitals, hotels, and similar buildings	84
Offices	100
Public buildings, schools, assembly halls, theatres, retail shops, workshops	112
Drill and ball rooms or floors subject to similar vibration	150
Warehouses, book stores, etc.	Not less than 224
Floors to carry machinery, printing presses, stacks of flour, paper, etc., water tanks, etc. . . .	Up to ½ ton, but each case must be investigated
Garages for light and private cars. . . .	Point load from axle loads up to 2 tons
Heavy lorries and tractors	Up to 11-ton wheel loads

Dead or Structure Loads additional to above.

Description.	Weight in lbs. per sq. ft. of Surface.
Concrete floor, reinforced concrete floor, granolithic, and asphalte	12 lbs. per inch of thickness
Breeze concrete	7½ ,, ,, ,,
Timber wearing surfaces	4–6 ,, ,, ,,
Nailing strips	2 ,, ,, ,,
Plaster ceiling	10 ,, ,, ,,
Timber floor for domestic buildings (boards and timber joists)	10 ,, ,, ,,

Roof Loads.

Superimposed or Live Loads.

	Equivalent Dead Load.
Wind load	See under "Wind Loading"
Flat roofs or roofs up to 20 deg. pitch .	56 lbs. per sq. ft. of surface, including wind, snow and ice
Roofs over 20 deg. pitch . . .	40 lbs. per sq. ft., including wind, snow and ice

Dead or Structure Loads additional to above.

Description.	Weight in lbs. per sq. ft. of Sloping Surface.
Asphalte	12
Boarding	3½ (per inch thickness)
Roofing felt	½
Slate battens	1
Slates	7–9
Tiles	12–18 (higher figure for small, i.e., plain tiles)

Glass	3½ (per ¼ in. thickness)
Glazing bars (metal)	3
Lead	5–7 (add for rolls)
Steel purlins	2–4
Timber rafter and purlins	7
G.I. Corrugated sheeting (22–18 gauge)	2–3
Concrete and ceilings	(see " Floor Loads ")
Asbestos slates	2½–3
,, corrugated sheeting	3–3½
Steel truss (approx.)	Total wt. $= 0{\cdot}75$ C.S. $\left(1 + \frac{S}{10}\right)$ lbs. C = centre of trusses in feet S = span of trusses in feet

Walls and Partitions.

	WEIGHT IN LBS. PER SQ. FT. OF VERTICAL WALL.
Brickwork	10 lbs. per 1 in. thickness
Breeze partitions	8 ,, ,, ,,
Plaster (each face)	9 ,, ,, ,,
Light timber-studded partitions complete	10 to 18 lbs. per sq. ft.
Concrete walls	12 lbs. per 1 in. thickness
Windows:	
Glass	14 ,, ,, ,,
Glazing bars	3–6 lbs. per sq. ft.

Lateral Pressures.

Wind pressures on flat vertical surfaces may be calculated from $p = 0{\cdot}0032\, v^2$

where p = pressure in lbs. per sq. ft.
v = velocity of wind in miles per hour.
This gives $p = 32$ lbs. per sq. ft. when $v = 100$
and $p = 40$,, ,, ,, ,, $v = 112$.

The upper portions and exposed members of structures should be designed for the above pressures, which may be reduced for the lower and sheltered portions.

To obtain the normal pressure (n) caused by the above pressure (p) acting horizontally on roofs or sloping surfaces inclined at angle θ to the horizontal employ the Duchemin Formula:

$$n = p\frac{2 \sin \theta}{1 + \sin^2\theta}$$

Earth pressures.—On vertical surfaces according to Rankine's formula $\frac{1 - \sin \theta}{1 + \sin \theta}$ for level ground surfaces.

Weight of earth per cu. ft. w.	Angle of repose of earth in degrees.	Pressure in lbs. per sq. ft. at any depth (h) in ft.
100	30	33 h.
100	35	27 h.
110	30	36 h.
120	30	40 h.

Foundation Pressures.

As it is often impossible to define precisely the nature of the ground forming a foundation, the following figures must only be taken as approximate and are subject to verification when sites are completely opened up.

Description of Ground.	Maximum Load in Tons per sq. ft.
Silt, morass, mud, peat, alluvial deposits, made-up ground tipped at least 10 years	0–½
Natural bed of soft clay, wet or loose sand, soft sandstones	
Natural bed of ordinary clay or confined sand	2
Natural bed of compact gravel, stiff clays (below frost level) and solid chalk	4
Natural beds of hard sandstones, limestones, etc.	6–10
Natural beds of igneous rocks (granites, whinstones, etc.)	15 upwards

Bearing Pressures.

Description of Bearing.	Average Safe Pressure in Tons per sq. ft.
Ordinary brick in lime mortar	3 (very variable)
„ „ cement „	5
Hard „ „	8
Blue „ „	12
Lime concrete (good)	8
Portland cement concrete (1 : 2 : 4) Granolithic bearing blocks Freestone „ „	12
Freestone ashlar masonry in cement	15
Granite „ „ „	25

Fusing of Concrete.

We have received the following from Mr. W. J. Rees, of the Department of Applied Science, University of Sheffield :—

"Sir,—I have read with interest the article in your October issue on 'The Fusing of Concrete' by Mr. A. E. Perkins.

"It would appear from the observations and analyses detailed in this article that the fusibility of the concrete is due to the character of the sand used in the aggregate. The fact that the best glass was found at the ground side of the foundation is probably due to the formation of glass at the upper surface of the concrete and its trickling through to the lower level where the temperature was such that solidification would take place.

"It is to be expected that with a temperature of over 1,600 deg. C. in the combustion chamber of the furnace, the temperature on the upper surface of the concrete would be between 1,000 deg. and 1,100 deg. C., or possibly even a little higher. It is unusual to have such a comparatively thin layer of firebrick and red brick between the high temperature combustion chamber and the concrete foundation. It is advantageous in all cases to interpose between the concrete foundation and the furnace structure a layer of insulating bricks. This makes a more efficient construction than the use of air ducts between the combustion chamber and the concrete foundation.

"In the particular construction referred to by Mr. Perkins the interposition of, say, a 3 in. insulating brick between the firebricks and the red bricks would be advantageous, and would prevent loss of heat by conduction into the foundation. It is becoming common practice at the present time to use a layer of insulating concrete in the foundation of a furnace. The insulating concrete is made from a mixture of cement with Keiselguhr or Diatomite. Both the insulating bricks and the insulating concrete in a 3 in. layer are sufficiently strong to carry the weight of any ordinary type of furnace.

"The abnormal result which Mr. Perkins describes should not in any way deter furnace builders from using concrete foundations for furnaces. It does, however, point to the importance for both furnace efficiency and foundation stability of adequate insulation and careful selection of the sand and aggregate used in making the concrete."

Materials for Concrete Road Construction.

By R. A. B. SMITH, A.M.Inst.C.E., A.C.G.I.

Fine Aggregate (*continued*).

CRUSHED gravel makes an excellent fine aggregate and gives good wearing properties; it is, in fact, better in this respect than uncrushed gravel.

Pea gravel is not suitable owing to its shape; the resultant surface is apt to be slippery even in paving flags.

The presence of more than 5 per cent. by weight of silt must be regarded as dangerous, and the material should not be used until a set of compression tests has been undertaken. A simple method of testing for silt is to stir the aggregate to be tested in a test tube with sufficient water to cover it. On settling, the silt will form a layer on top of the aggregate, and if the tube is graduated it is an easy matter to ascertain the proportion of silt to aggregate.

Loam or clay when found in a fine sand is likely to reduce the strength; on the other hand, a small percentage in a coarse sand does not seem detrimental and quite good compressive strength results have been obtained. Generally speaking, not more than 5 per cent. should be allowed in the latter case, and in the former judgment must be based on the results of compression tests.

The specification for fine aggregate adopted by the American Society for Testing Materials requires that tensile or compressive tests of the fine aggregate at 7 and 28 days shall show strengths not less than that of 1·3 standard sand mortar of the same consistency made with the same cement.

A simple test for voids is that recommended by the British Portland Cement Association, and is as follows:—

Take a glass cylinder (2 in. to 5 in. diameter, according to size of aggregate) and graduate it (a varnished paper scale will suffice) as shown in *Fig.* 1 so that parts A and B contain equal volumes. Stand the cylinder on a level surface and pour water in to fill part " A," tapping the vessel gently on its support so as to compact the aggregate in the water. The water surface will now rise to, say, " C," dividing part " B " into two portions—that filled by the water displaced by the aggregate and the upper part representing voids in the aggregate. If the scale is graduated as shown the percentage of these voids to the volume of aggregate (A) can be read off directly. In the sketch this is 45 per cent. For the most accurate results damp aggregate should be used to prevent any absorption of the water in the cylinder.

Coarse Aggregate.

The chief materials used as coarse aggregate for concrete roads are: (1) Granite; (2) whinstone, basalts; (3) limestone; (4) gravel or ballast; (5) sandstone; (6) slags, etc., and clinker.

Granite.—The best granites are obtained from the districts around Aberdeen and Leicester and in the island of Guernsey. All have their distinctive features, but they are all free from any of the impurities such as FeS_2 which would be detrimental to the concrete. Granite is usually grey coloured, and of coarse texture, and the specific gravity is 2·65 to 2·70; it forms an excellent aggregate.

Whinstone and Basalts.—Most of the roads constructed in Scotland are composed of whinstone, which is tougher than granite and in every way a very suitable aggregate, standing up to steel-tyred traffic practically as well as granite. All the basalts are hard enough and not inclined to be brittle, so that if the choice of either granite or basalt is possible for the surface the latter may be chosen if cheaper. A brittle stone is apt to crack under a tyre, more particularly in frosty weather, so that eventually pieces are missing in various parts of the surface; this is no great defect but it is perhaps annoying.

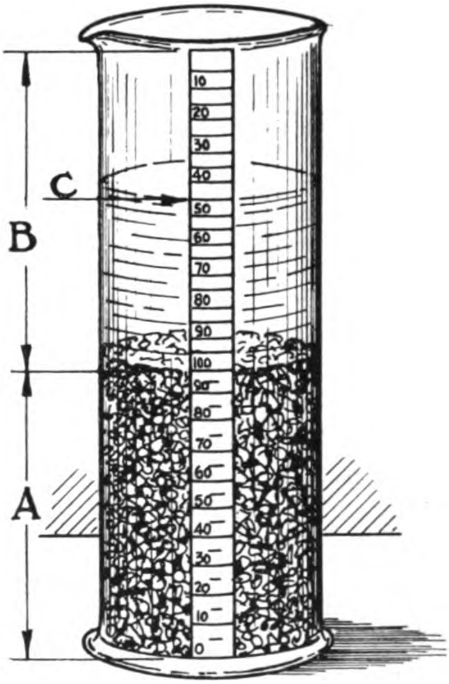


Fig. 1.

The specific gravity of basalts, traps, etc., generally varies from 2·8 up to 3·2. They are dark green to black in colour, and of closer texture than granites.

Fans are now usually employed at quarries to remove the dust, which has a market value as a filler for bituminous preparations. When fanning is not done it is advisable to specify washed material, as otherwise the combination between the stone and the cement is not so satisfactory; more than once this defect has led to unfounded criticism of the cement.

Limestone.—Limestone is usually a very suitable aggregate. The higher the specific gravity, the more satisfactory it is. Those of low specific gravity are rarely, if ever, suitable for the top surface of a concrete road, being too soft (specific gravity may be as low as 2) and liable to polish and produce a dangerously slippery surface. It must also be realised that the fine dust which clings to the surface of a piece of limestone is particularly objectionable and may reduce the strength by 40 per cent. unless removed by washing.

Gravel and Ballast.—All gravel and ballast pits may be considered potential sources of coarse aggregate, but one occasionally runs across a pit where the percentage of soft sandstone is so high that the material has no wearing value at all and must be refused for one-course concrete road construction, though still admirable for the bottom course in two-course construction. Gravel has a specific gravity in the neighbourhood of 1·75.

Sandstone.—When mica is present in a sandstone it is not likely to produce a strong concrete, and tests should first be made to obtain some knowledge of its compressive strength. When quartz particles are the chief constituent, then sandstone is likely to be suitable. An easy test, giving fairly reliable results, is to boil a small piece about the size which would pass a ⅜-in. mesh. If it immediately disintegrates it can have little if any value.

Slags and Clinker.—Slags are most variable, and must be regarded with suspicion until tests in the laboratory have shown that the material is free from sulphur or any other impurity. Cold-blast slags from steel works rarely contain sufficient impurity to be other than suitable, but there are many slag tips in this country which must not, unfortunately, be used with cement.

Generally slag is hard, though full of tiny air holes, and compression tests give good results. These last may be good in which sulphur is present, as the action between the SO_2 and the cement may only take place over a number of years.

Clinker must be carefully selected if it is to be used in concrete. Boiler ashes are not suitable, as they almost inevitably contain particles of coal; clinker, however, obtained from destructors is suitable, more especially if obtained in winter. Some figures recently obtained in such a case are sufficiently interesting to be repeated:—

A slab was made of 3 parts of screened clinker to 1 part of rapid-hardening Portland cement gauged with 13·5 per cent. of water.

	lbs.	ozs.
Weight before abrasion	43	3
Weight after 48 hours' abrasion . . .	41	12
Loss in weight	1	7
Percentage loss	3·3 per cent.	

Not only is this clinker sound in its compressive strength, but it also shows excellent resistance to abrasion when it is considered that no higher results are asked by the British Standard Specification for paving slabs. It is, however, recommended that when clinker or slag is used as the aggregate for concrete road construction the use of reinforcement should be avoided ; if the use of reinforcement seems unavoidable in some portions of the work, then clinker or slag should be substituted by another material which is known to be perfectly harmless.

The value of a knowledge of the specific gravity of a substance is in the fact that it offers an easy method of checking the voids in smaller or fine aggregates.

If W equals the weight of a cubic foot of material,
S equals the specific gravity of the material
The weight of a cubic foot of water is taken as 62·3 lbs.

Then the percentage of voids equals $\left(1 - \frac{W}{62{\cdot}3 \times S}\right) 100$.

If the material contains moisture it should be first dried.

(*To be continued.*)

Rapid Construction.

An interesting contract has just been completed under exceptional circumstances at Liverpool for the Mersey Railway Company. For some time the facilities for handling passenger traffic during the rush hours at Liverpool Central (Low Level) Station have been inadequate, and the management considered several schemes for relieving the congestion. It was eventually decided to widen the platform and provide additional staircase accommodation ; arrangements were made for carrying out the work during the summer of 1926, but owing to the coal and general strikes of that year the scheme was postponed.

It was realised that in order to prevent undue dislocation of traffic the whole of the work in the platform widening would have to be completed in one week-end. By Board of Trade Regulation only fireproof materials could be used, but by the use of steelwork, precast hollow beams and concrete flagging the scheme was carried through within the stipulated time. Messrs. Redpath, Brown & Co., Ltd. were the main contractors, and the concrete work was carried out by Messrs. Precast Concrete, Ltd. (Huddersfield), who were responsible for supplying and fixing their patent " Hollocast " floor, and " Nonslip " paving flags (Nonslip Stone Co., Halifax).

Work was commenced by the Railway Company at 10 o'clock on Friday night, September 30. This consisted in the entire removal of the track alongside the existing platform and the laying of new points, crossings, and track to accommodate the traffic to the extension. The erection of the steel super-structure was commenced by Messrs. Redpath, Brown & Co., Ltd., at 6 a.m. on Saturday, and one hour later Messrs. Precast Concrete, Ltd., commenced laying the " Hollocast " floor beams, immediately following with the concrete flags. The whole of the work was completed by 6 a.m. on Monday, October 3 (48 hours), and the new staircase was fixed during the following week-end. The new platform had to be available for traffic immediately on completion, and rapid hardening cement was used throughout.

The extension to the platform was 332 ft. long, by up to 13½ ft. wide, and was carried out under the direction of Mr. J. Shaw, M.Inst.C.E., the General Manager of the Railway Company.

New Types of Porous Concrete.

"ICE CONCRETE."

THE references to " ice concrete " that have appeared recently in the Press are discussed by Mr. H. E. Wennstrom in a recent issue of " Pit and Quarry." There are, he says, two principles which have been utilised in the production of porous concrete.

The first depends upon the generation of a gas during the process of setting, brought about by a chemical reaction resulting from the action of certain ingredients in the cements in combination with water upon certain added materials. The latter must be of such a nature that a gaseous substance results from their interaction with water, generally in the presence of alkalis or alkaline substances. As examples of materials of this type may be mentioned certain metals in a fine state of subdivision, such as zinc, aluminium, magnesium, calcium, etc., and carbides of a type which undergo slow decomposition in contact with water, such as aluminium carbide.

The second principle involves the use of a substance which is solid at a low temperature but liquefies with the rise of temperature, allowing the cement to form an outer coating while in the solid state, and of such a nature that when it assumes the liquid phase it enters into chemical combination with the cements. A substance of the type is water, employed in the form of ice. Hence the product obtained by the application of this principle has been termed " ice concrete," whereas what is obtained by making use of the first principle known as " gas concrete."

Several patents have been granted in which the application of these principles is involved. One of these patents claims that porous concrete products are obtained by adding to the cement or mortar in the dry state aluminium or a similar metal in a very fine state of subdivision, the object being to obtain an evolution of hydrogen before the cement or mortar hardens. The production of pores in the resultant mass occurs due to the passage of the gas through the material while in a plastic condition, and suggests the employment of hot water or the addition of a small amount of caustic alkali in order to accelerate the evolution of the gas, the mortar being prepared in the usual manner with or without the addition of sand.

The process consists of the addition to the cement of a mixture called " slate-lime " and a powdered metal, which is adapted to generate gas from the resultant mixture on the addition of water. Aluminium, zinc and magnesium are metals of this type. " Slate-lime " is an intimately finely-divided mixture of calcined slate and lime, as, for instance, 50 per cent. by weight of each or 60 per cent. by weight of lime and 40 per cent. by weight of calcined slate. The calcined slate and lime should preferably first be finely powdered separately, and then ground together.

When the gas-generating metal powder is added to the cement, together with the " slate-lime," the product obtains a high degree of porosity and a uniform composition, which is due to the fact that the whole mass consists of a finely divided binding agent and water. The mass will thus not contain any particles which will sink to the bottom, but only very light and fine particles which will remain uniformly suspended in the liquid mass during the hardening of cement ; moreover, the " slate-lime " will not cause any saline efflorescence on the surface of the bricks made of this mixture, as the calcined slate will bind any salts likely to cause an efflorescence. The addition of " slate-lime " is claimed to secure the advantage that the cement can be mixed therewith without reducing the strength of the product.

The introduction into the mixture of raw materials of a powdered metal of the type mentioned in very small quantities is generally made in amounts of less than 1 per cent. The introduction of the metal may be carried out at any stage of the incorporation of the raw materials ground together with the latter so that an intimate mixture is effected. When water is added to such a mixture, a chemical reaction takes place resulting in the generation of large quantities of gas which cause an increase of the volume of the mass. This takes place before the " binding " sets in, and when the material has been hardened " a porous stone-like material" is obtained.

The addition of water of a temperature of from 87 degrees to 104 degrees F. is required in order that the reaction may take place more rapidly, and that a larger quantity of gas may be produced. In order to reduce the period for the setting, it is convenient to add substances adapted to this purpose, such as sodium carbonate and aluminous cement. The aluminous cement causes very rapid hardening and should be added only in a very small quantity, for example, 2 to 5 per cent.

Two formulæ as examples for the production of a porous concrete of the type under consideration are as follows: (1) 70 to 85 parts by weight of "slate-lime," 15 to 30 of Portland cement, 0·25 of zinc dust, and 50 to 100 of water. (2) 60 to 80 parts of cement, 40 to 20 of "slate-lime," 0·15 of aluminium powder, and 40 to 80 of water.

It is claimed that material manufactured according to this procedure has a high degree of porosity, and that the pores are fully separated from one another by means of partition walls. On account of this fact air cannot circulate through the material, since the different cells containing the generated gas are wholly closed. The material has a very low weight for volume, the specific gravity being 0·5. Due to the high porosity of the material, relatively small quantities of raw material will suffice for its manufacture.

The material has large heat-insulating power, which makes it very suitable for use in the construction of exterior walls of buildings, and it is easily workable, capable of being turned out in the form of bricks, slabs and the like. It can be cut soon after having been manufactured.

"Ice Concrete."

The second method or principle in the production of a porous concrete involves the use of water in the form of ice, and results in the production of so-called "ice concrete." One advantage of "ice concrete" over that of "gas" is that the former can be shaped in the course of manufacture, whereas the latter can be cut into desired forms only after it has hardened.

"Ice-concrete" is made by mixing snow, crumbled ice, or artificial hailstones with quickly-setting cement, mortar or plaster. This surrounds or coats and insulates the snow or ice particles used to produce the pores in the intended mass, and at the same time this coating material prevents the snow or ice particles from melting too quickly, thus facilitating the tamping or pressing of the mass into the desired shape. Should it be desired to mould the ice-concrete, water is added until the mixture becomes fluid, but not before the snow or ice particles have been coated by the hydraulic substance. It is possible to predetermine the size and quantity of the pores in the product by using a greater or a lesser proportion of snow or ice particles in the mixture.

After tamping or moulding, the objects are taken into a warm room, where the hardening can begin at once and the snow or ice particles can begin to melt, giving the mass the humidity which cement, for instance, needs in order to harden. As the snow or ice particles coated with cement meet the water, which is partly absorbed by the mass and partly evaporates, the mass becomes porous to the desired degree, because it cannot shrink as this is prevented by the already hardened insulating layer, which coats or encloses the snow or ice particles.

New Designing Firm.—The firm of Bierrum & Partners has been established to carry on business as engineers and contractors specialising in reinforced concrete work with offices at 92 Victoria Street, London, S.W.1. The firm will undertake the design as well as the erection of all kinds of reinforced concrete structures, taking the entire responsibility. The partners of the firm are Messrs. H. A. Bierrum, H. Ingerslev, and O. Westergaard.

DATA FOR PRICING REINFORCED CONCRETE.*

MATERIALS DELIVERED 4 MILES FROM CHARING CROSS.

		s.	d.
Best Washed Sand	per yard	13	6
Clean Shingle, ¾ in. mesh	,,	12	6
,, ,, ½ in. mesh	,,	13	6
Thames ballast	,,	10	6
Broken brick (¾ in.)	,,	11	6
Best British Portland Cement (delivered London area)	per ton 53s. to	55	0
Rapid-Hardening Portland Cement	delivered London 10s. per ton extra		
"Super-Cement"	per ton 83s. to	88	0
"Lightning" Brand Aluminous Cement	,, 100s. to	105	6
Ciment Fondu	works f.o.r.	95	0

Boarding for Shuttering—

		Sawn. s.	Sawn. d.	Wrot. s.	Wrot. d.
1 in.	per square	23	6	27	6
1¼ in.	,,	29	6	33	6
1½ in.	,,	35	6	41	0

Sawn Timber for Struts and Supports—

3 in. by 4 in.	from £22 per standard
3 in. by 6 in. and 3 in. by 7 in.	,, £20 ,, ,,

Mild Steel Rods for Reinforcement—

		s.	d.
⅝ in. to 2¾ in. Rounds	per cwt.	10	6
7/16 in. to ½ in. Rounds	,,	10	9
⅜ in. Rounds	,,	11	0
¼ in. Rounds	,,	12	0

Breeze Slabs per yd. super: 2 in., 1/11; 2½ in., 2/4; 3 in., 2/9; 4 in., 3/6.

MATERIAL AND LABOUR, INCLUDING 10 PER CENT. PROFIT.

(Based on Contracts up to £2,000.)

Portland Cement Concrete well mixed in proportion 1 : 2 : 4—

		s.	d.
Do. do. in foundation	per foot cube	1	9
Do. do. in columns	,, ,,	1	11
Do. do. in beams	,, ,,	2	1
Do. do. in floor slabs 4 in. thick	per yard super	5	8
Do. do. in floor slabs 5 in. thick	,, ,,	7	0
Do. do. in floor slabs 6 in. thick	,, ,,	8	6
Do. do. in floor slabs 7 in. thick	,, ,,	9	10
Do. do. in walls 6 in. thick	,, ,,	8	2

(Add for hoisting 3s. 6d. *per yard cube above ground-floor level. Add for "Ferrocrete"* 1s. 10d. *per yard cube.)*

Steel Reinforcement, including Cutting, Bending and putting into Position and securing with Stout Binding Wire—

		s.	d.
From ¼ in. to ⅜ in.	per cwt.	22	6
,, 7/16 in. to ½ in.	,,	21	6
,, ⅝ in. to 2¾ in.	,,	20	6

EXTRA LABOUR TO BENDS in ¼-in. rods, ½*d.*; ⅜-in. rods, 1*d.*; ½-in. rods, 1¼*d.*; ⅝-in. rods, 1½*d.*; ¾-in. rods, 1¾*d.*; ⅞-in. rods, 2*d.*; 1-in. rods, 2¼*d.*; 1⅛-in. rods, 3*d.*; 1¼-in. rods, 3½*d.*; 1⅜-in. rods, 4½*d.*; 1½-in. rods, 6*d.* (per bend per cwt.).

EXTRA LABOUR TO HOOK BENDS: ¼ in., 1*d.*; ⅜ in., 2*d.*; ½ in., 2½*d.*; ⅝ in., 3*d.*; ¾ in., 3½*d.*; ⅞ in., 4*d.*; 1 in., 4½*d.*; 1¼ in., 6*d.*; 1½ in., 7*d.* (per bend per cwt.).

Shuttering—

		s.	d.
Shuttering and Supports for Concrete Walls (both sides measured)	per square	59	0
Centering to Soffits of Reinforced Concrete Floors and Strutting, average 10 ft. high	per square	55	0
Do. do. in small quantities	per ft. super	0	10
Shuttering and Supports to Stanchions for easy removal, average 18 in. by 18 in.	per ft. super	0	11½
Do. do. as last, in narrow widths	,, ,,	1	1½
Do. do. to sides and soffits of beams, average 9 in. by 12 in.	,, ,,	1	1½
Do. do. as last, in narrow widths	,, ,,	1	3½
Raking, cutting, and waste to shuttering	per ft. run	0	3
Labour, splay on ditto	,, ,,	0	2
Small angle fillets fixed to internal angles of shuttering to form chamfer	,, ,,	0	3

WAGES.—The rates of wages on which the above prices are based are:—Carpenters and joiners, 1/9½ per hour; Carpenters working on old shuttering, 1/10½; Labourers on building works, 1/4½; Men on mixers and hoists, 1/5½; Bar-benders, 1/5½.

[* This Data is specially compiled for *Concrete and Constructional Engineering*, and is strictly copyright.]

Prospective New Concrete Work.

Ashby-de-la-Zouch. — *Reservoir.* — The U.D.C. has purchased a site on which to construct a 3,000,000-gallon reservoir.

Atherstone—*Houses.*—The Atherstone (Warwick) R.D.C. is considering a scheme for the erection of 70 houses in Westwood Road, Atherstone.

Balmakelly.—*Concrete Bridge.*—The Laurencekirk District Committee proposes to construct a reinforced concrete bridge on the main Montrose Road at Balmakelly.

Barking.—*Houses.*—The U.D.C. is considering a scheme for the construction of 400 houses on the Upney estate.

Bedford.—*Reservoir.*—The Waterworks Committee has recommended the T.C. to spend £18,000 on the construction of a 5,000,000-gallon reservoir.

Belfast.—*Jetty.*—The Harbour Board proposes to construct a discharging jetty at Connswater.

Bury.—*Houses.*—The T.C. proposes to purchase Perry's Barn on which to erect 132 houses.

Chertsey.—*Houses.*—The U.D.C. has instructed the Architect to prepare plans for the construction of 50 houses in Pyecroft Road.

Cobham.—*Road.*—The Epsom R.D.C. proposes to construct a 40-ft. road off Sandy Lane, Cobham.

Coleford.—*Road.*—The Frome R.D.C. proposes to construct a road at Coleford, at an estimated cost of £6,000.

Collycroft.—*Houses.*—The Foleshill R.D.C. proposes to build 50 houses at Collycroft.

Cork.—*Concrete Wharf.*—The Harbour Board proposes to spend £27,000 on reconstructing Victoria Wharf in reinforced concrete.

Coulsdon.—*Houses.*—The Coulsdon and Purley U.D.C. proposes to erect 50 houses at Coulsdon.

Darlaston.—*Houses.*—A deputation is to meet the M.H. with a view to erecting 380 houses on a site off Catherine's Cross.

Egham.—*Houses.*—The U.D.C. has been recommended to erect 50 houses.

Exeter.—*Swimming Pool.*—The Corporation has instructed the Surveyor to prepare plans for the construction of a swimming pool at the Head Weir bathing ground.

Fleetwood. — *Dock.* — The London Midland & Scottish Railway Co. proposes to carry out extensions at Fleetwood Dock.

Galloon Island.—*Bridge.*—The Surveyor to the Fermanagh C.C. has submitted a scheme for the construction of a bridge at Galloon Island. The cost is estimated at £7,000.

Hull.—*Footbridge.*—The Corporation has instructed the Engineer to prepare plans for the construction of a footbridge over the railway sidings to connect up Hessle Road with the foreshore of the Humber.

Kingussie.—*Bridge.*—The T.C. proposes to spend £1,200 on the construction of a bridge over the Guynack Burn.

Kirkcaldy.—*Houses.*—The T.C. is considering a proposal to build 100 houses in Massereene Road and Links Street.

Leatherhead.—*Houses.*—The U.D.C. has decided to build 24 houses on the Woodbridge estate.

Littlehampton.—*Reservoir.* — The T.C. has been recommended to construct a reservoir at Batworth Park. The cost is estimated at £9,500.

London (Woolwich). — *Houses.*— Application has been made for sanction to erect 100 houses by direct labour on the Eltham housing estate.

Market Harborough.—*Bridge.*—The Leicestershire C.C. proposes to construct a bridge over the Welland at Northampton Road.

Mullaghboy. — *Reservoir.* — The Clones U.D.C. proposes to provide a reservoir at Mullaghboy.

Newry.—*Bridge.*—The U.D.C. has applied to the Ministry of Home Affairs for permission to borrow £7,000 for the erection of a bridge to replace Godfrey Bridge.

MISCELLANEOUS.

SITUATION VACANT.

ASSISTANT for Concrete Engineer wanted for London. State age, salary, and full particulars to Box 1270, Concrete and Constructional Engineering, 20 Dartmouth Street, Westminster, S.W.1.

BACK NUMBERS WANTED.

CONCRETE & CONSTRUCTIONAL ENGINEERING Vols. 1 to 18 complete or odd volumes. Particulars to T.F.D., Wm. Dawson & Sons, Ltd., Second-hand and Rare Book Dept., Cannon House, Breams Buildings, E.C.4.

NEWTON ABBOT. — *Houses.* — The U.D.C. proposes to build 60 houses on the Broadlands estate.

OXFORD.—*Reservoir.*—The Corporation is considering a scheme for the provision of an additional reservoir adjoining the existing one at Headington.

PETERBOROUGH. — *Bridge.* — The T.C. is considering a scheme for bridging the river and the L.N.E. Railway at Bridge End.

POOLE.—*Defence Works.*—A reinforced concrete groyne is to be constructed at Sandbanks. The cost is estimated at £150.

PORTOBELLO.—*Pier.*—The Edinburgh Corporation is considering a scheme for the construction of a pier at Portobello.

ROUDHAM.—*Bridge.*—The Norfolk C.C. Highways Committee is negotiating with the L. & N.E. Railway Company for the provision of a bridge at the Roudham level crossing.

SANDWICH.—*Road.*—The T.C. proposes to construct a road from the Causeway to Moat Sole.

SWADLINCOTE. — *Reservoir.* — The U.D.C. has purchased about 4 acres of land on which to construct a 3,000,000-gallon reservoir.

THORNBURY (GLOS.).—*Houses.*—The R.D.C. has applied for permission to borrow £15,000 for the construction of 40 houses in the surrounding parishes.

WILLINGTON.—*Houses.*—The U.D.C. is considering a scheme for the erection of 30 houses.

Tenders Accepted.

BELFAST.—*Concrete Culvert.*—The Corporation has accepted the tender of Mr. B. Stafford, Ulsterville Terrace, Belfast, at £11,446, for the construction of about 480 lineal yds. of 54-in. reinforced concrete pipe culvert.

BELFAST. — *Concrete Pipe Culvert.* — The C.B. has accepted the tender of Messrs. Musgrave & Co., Ltd., Belfast, at £1,121 5s., for the construction of about 480 lineal yds. of reinforced concrete pipe culvert, together with manholes and junction chamber.

BERRYDEN (ABERDEEN). — *Concrete Reservoir.*—The Northern Co-operative Society, Ltd., have accepted the tender of Messrs. Clark & Chapman, Charlotte Street, Aberdeen, for the construction of a 50,000-gallon reinforced concrete reservoir.

BODENHAM.—*Concrete Wall.*—The Leominster R.D.C. has accepted the tender of Mr. H. J. Witham, Hereford, at £585, for the construction of a reinforced concrete retaining wall alongside Bridge Road, Bodenham. Other tenders submitted : E. W. Wilkes & Son, Ltd., £667 ; W. F. Greenley & Son, £730 ; W. H. Peake & Son, £743 ; W. Wall, £754 ; Beaven & Hodges, £895 ; J. Watkins & Son, £945 ; C. W. Ellis, £1,120 ; J. Cutler, £1,749.

CRADLEY HEATH (STAFFS.)—*Concrete Sewer.*—The Upper Stour Valley Main Sewerage Board has accepted the tender of Mr. W. H. Rogers, Moat Street, Willenhall, for the construction of about 500 yds. of 30-in. and 2,300 yds. of 27-in. reinforced concrete pipe sewer with manholes.

EAST KERRIER.—*Concrete Reservoir.*—The R.D.C. has accepted the tender of Mr. C. Trethowan, Constantine, at £210 for the construction of a concrete reservoir.

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FISHBURN.—*Concrete Water Tank.*—The Sedgefield R.D.C. has accepted the tender of Mr. G. W. Lazenby, Ferryhill, at £290, for the construction of a reinforced concrete water tank.

GRIMSBY.—*Quay Wall.*—The Corporation has accepted the tender of Messrs. Hewins & Goodhand, Grimsby, at £875, for the construction of a mass concrete quay wall at the River Head Wharf.

IPSWICH.—*Quay.*—The Dock Commission has accepted the tender of Messrs. Simplex Concrete Piles, Ltd., at £49,003 for the construction of the extension of the Cliff Quay. Other tenders submitted: H. M. Murray & Co., £50,105 ; Allison Rattray & Co., £50,628.

LONDON. — *Concrete Houses.* — The Woolwich B.C. has accepted the tender of Messrs. John Laing & Son, Ltd., for the erection of two concrete houses on the Council's housing estate at Eltham.

LONDON (FINCHLEY).—*Concrete Sewer.*—The U.D.C. has accepted the tender of Messrs. W. & C. French, Buckhurst Hill, for the construction of about 190 yds. of 30-in. concrete tube soil sewer in Cyprus Gardens, Finchley.

LONDON.—*Foundations.*—The L.C.C. has accepted the tender of Messrs. G. Walker & Slater, Ltd., at £3,422, for the construction of foundations for the central block of dwellings at Ossulston Street, St. Pancras. Other tenders submitted: Holliday & Greenwood, Ltd., £5,218 ; Howard Farrow, Ltd., £5,062 16*s.* 6*d.* ; Wm. Muirhead, Macdonald Wilson & Co., Ltd., £5,053 18*s.* 7*d.*; Patman & Fotheringham, Ltd., £5,027 ; Perry & Co. (Bow), Ltd., £4,993 ; Wm. Moss & Sons, Ltd., £4,976 ; J. Carmichael (Contractors), Ltd., £4,880 ; J. Mowlem & Co., Ltd., £4,826 ; Leslie & Co., Ltd., £4,786 ; Holloway Bros. (London), Ltd., £4,779 ; Albert Monk, £4,775 ; Wilson Lovatt & Sons, Ltd., £4,446 17*s.* 4*d.* ; Chessums, Ltd., £4,385 ; Allen Fairhead & Sons, Ltd., £4,363 ; W. Lawrence & Son, Ltd., £4,234 ; D. G. Somerville & Co., Ltd., £4,201 18*s.* 5*d.* ; G. E. Wallis & Sons, Ltd., £4,080 ; Rowley Bros., Ltd., £4,015 ; John Laing & Son, Ltd., £3,956 ; Hill & Gurr, £3,950 ; Thos. Higgs, £3,826 ; R. J. Rowley, £3,822 ; J. E. Billings & Co., Ltd., £3,538 ; E. D. Winn & Co., £3,500.

PLYMOUTH. — *Concrete Tubes.* — The Corporation has accepted the tender of Messrs. J. Smith Bros., Ltd., Half Moon Lane, S.E.24, for the supply of 138 yds. of 42-in. and 212 yds. of 39-in. reinforced concrete tubes.

RAINFORD (LANCS).—*Concrete Wall.*—The U.D.C. has accepted the tender of Mr. J. Pilkington, Rainford, at £201, for the construction of a 96-ft. reinforced concrete retaining wall.

SOUTHEND-ON-SEA. — *Pier Improvement.*—The T.C. has accepted the tender of Messrs. Peter Lind & Co., at £43,350, for pier improvement works.

TILBURY.—*Concrete Road Works, etc.*—The U.D.C. has accepted the tender of Messrs. W. & C. French at £4,770, for the construction in reinforced concrete of Chadwell Road, together with artificial stone paving, and surface water sewers, etc. Other tenders submitted: W. Iles, £6,018 ; W. E. Walsham, Ltd., £5,555 ; W. & C. Sticking, £5,235 ; G. Wimpey & Co., Ltd., £4,990 ; Chittenden & Simmons, Ltd., £4,997 ; W. H. Wheeler & Co., Ltd., £4,964 ; Triangular Construction Co., Ltd., £4,800 ; A. Blair Lyell & Co., Ltd., £4,795 ; G. J. Anderson, £4,655.

YSTALYFERA. — *Concrete Weir.* — The tender of Messrs. Mackenna, Ltd., Heathfield Street, Swansea, for the construction of a concrete weir across the River Twrch has been accepted.

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Recent Patent Applications.

276,068.—A. S. Lewenstein : Floors and flooring blocks or units.

276,069.—A. H. Barnes and E. R. Hillier : *In situ* concrete building construction.

276,241.—H. P. Powell : Walls and partitions for buildings.

276,438.—British Portland Cement Manufacturers, Ltd., J. H. Baxter, M. K. Bamber, and W. J. Dickinson : Manufacture of cement.

276,707.—A. Godenir : *In situ* concre construction.

277,126.—E. C. Caley and C. Down Concrete wall construction.

277,192.—W. Wilson : Ornamental concrete.

277,252.—R. J. Lyne : Forms for monolithic construction.

277,513.—D. L. Irwin and Ruberoid Co Ltd. : Expansion joints for concre roads.

New Companies Registered.

Dartford Concrete, Ltd. (225131). Registered October 17. Manufacturers cement products, etc. Nominal capital, £4,000. Directors : J. F. Robertson, 10 Marina, St. Leonards-on-Sea ; R. M. F. Robertson, 11, Lancaster Gate, W.2.

Midland Slab and Adamant Co., Ltd. (225140). Registered October 1 Heneage-street, Birmingham. Manufacturers of concrete goods, etc. Nominal capital, £2,000. Directors : E. Richards, 18, Easy-row, Birmingham ; C. Wright, 1 St. Mary's-road, Harborne, Birmingham.

New Reinforced Concrete Bridges in Surrey.

In connection with the Kingston by-pass road, two road bridges over the Souther Railway Main Line and Epsom Branch Line at Raynes Park have been built b the Surrey County Council. The work was commenced in September, 1926.

The bridges comprise two series of four spans each, the length between the abutment walls spanning the main line being 176 ft., and that between the abutme walls spanning the branch line 164 ft. 6 in. The width between parapet walls 60 ft., and includes two 10-ft. footways. The height from top of rail to crest o carriageway is about 21 ft. 3 in.

The construction work was carried out under conditions made difficult by th frequent passing of trains—on the main line on an average of about one train pe minute. The proximity of high-tension " live " rails further added to the difficulties. The contractors were Messrs. Christiani & Nielsen, of Westminster. Th aggregate was ¾-in. washed crushed river ballast and washed river sand supplied by Messrs. William Boyer & Sons, Ltd., of Irongate Wharf, Paddington, W.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XXII. No. 12. LONDON, DECEMBER, 1927.

EDITORIAL NOTES.

Quality of Cement and the Strength of Concrete.

THE United States has generally been looked to for world leadership in concrete technique, and it is therefore surprising to find at this stage of development that the United States Bureau of Public Roads and the Michigan State Highway Department have conducted jointly an investigation designed to discover the effect of the quality of cement on the strength of concrete. To raise such a question implies doubts as to whether the British Engineering Standards Committee has not been beating the air in its labours towards raising the standard of quality of British Portland cement, and whether British cement manufacturers have not been wasting money in laying down new plant for the improvement of quality of cement. Some relief is therefore felt when it is found that the report of the investigation in question shows the results to be in accordance with the accepted view that a stronger cement makes a stronger concrete.

For the tests in question three grades of cement were used, giving 180 lbs., 255 lbs., and 325 lbs. per square inch respectively for tensile strength at 7 days when mixed with 3 parts of standard sand, and, although none of these qualities is equal to the modern British Portland cement, they serve the purpose of illustrating the effect of quality of cement upon concrete strength. The quality of the concrete made from such cements was judged by tests for tension, compression, and flexure, using a standard road mixture of 1 : 2 : 3½. The tension test-pieces were 6-in. diameter, the compression test-pieces were 6-in. by 12-in. cylinders, and the flexure test-pieces were beams 6 in. by 6 in. by 36 in.

As already indicated, the strengths of the concretes made from the three grades of cement were in proportion to the quality of the cement as judged by the usual 7-day tensile test, but the investigation also enables a moral to be drawn in connection with the advantage of using high-quality cements for road work. The three grades of cement referred to were apparently normal cements on the United States market, and the report points out the significance of the wide variations in strength from the standpoint of design of concrete roads. Assuming a required modulus of rupture of 600 lbs. per square inch in connection with the edge thickness of a concrete pavement, this modulus was attained in approximately 12 days when the highest strength cement of the three grades was used ; but only in 28 days when the medium-strength grade was employed ; and not even in 6 months when the low-strength cement was used. This is a very striking example of the value of high-strength cement such as the rapid-hardening cements manufactured in this country, and it is possible to appreciate the reason why a British rapid-hardening cement was employed for the re-paving of New York's Broadway. It must be emphasised that the figures in the report referred to deal with comparatively low grades of cement, but there is no doubt that the same rule applies upon the higher levels common to British cement manufacture. The stronger the cement the stronger the concrete and the more rapidly it can be put into service.

Cast Iron as Reinforcement.

In his paper on " Hooped Cast Iron " which we publish in this issue, Mr. R. N. Stroyer draws attention to a combination of materials of which very little is known in this country, but which has been used in a number of important structures during the past twenty years. The reason for using cast iron in preference to steel in compression members is, of course, in the last instance cheapness, cast iron being about half the price and having twice the strength of steel, and every structure that has been executed in hooped cast iron has no doubt had to face a sharp competition with steel and reinforced concrete. That it has successfully done so in spite of the usual prejudice against any new proposal speaks for the efficiency and safety of the material, and as its use seems to be an established fact on the Continent there does not seem to be any reason why we in this country should not take advantage of a system of reinforcement, which, in addition to cheapness, offers some remarkable possibilities for reducing the bulk of concrete compression members.

The L.C.C. column may suffer from heaviness unless costly steel reinforcement is introduced; with hooped cast iron it is stated that a 12-in. column may be used from roof to basement in a building taking loads up to 250 tons; so that it is possible to visualise the standardisation of columns with this system, inasmuch as two sizes, say 12-in. and 16-in., would probably cope with all building loads up to 400 tons.

The redeeming clause mentioned in the Austrian regulations, which allows the use of any new construction provided an actual factor of safety of 3 is proved by test, has much to commend it, and the introduction of a similar clause in our regulations would do much to further research work on new methods of construction and their practical application in every-day structures.

Curing Concrete.

By J. SINGLETON-GREEN, M.Sc., A.M.I.Mech.E.

THE actions which take place during the setting and hardening of Portland cement are very complicated, but the summary below probably represents fairly accurately the action of the chief constituents:

(*a*) Tricalcium aluminate and 5 : 3 calcium aluminate hydrate during the first 24 hours and cause the setting and hardening during this period. If the cement is disturbed after it has been laid, these actions alone are affected.

(*b*) Tricalcium silicate commences to hydrate after the first 24 hours and continues for about 7 days.

(*c*) Dicalcium silicate commences to hydrate after about 7 days and continues almost indefinitely.

None of the above actions can take place in the absence of water, and it is shown below that concrete increases little in strength unless it is kept moist. When the aluminate actions take place undisturbed the cement tends to retain its moisture more tenaciously than when these actions are interrupted, and so the hydration of the silicates is further affected. These considerations bring us to the practical point that it is even more important to keep a trowelled face wet than an untrowelled one.

It is recommended that concrete be kept wet for at least fourteen days, if possible. In any case, it should be protected from wind and sun, which would evaporate the water necessary for its complete setting.

The effects of varied curing conditions have been carefully studied by Mr. Herbert J. Gilkey, and the conclusions below are summarised from his paper.*

(1) The longer concrete is kept moist after being placed, the better. To be more specific, concrete which is dry after 7 days' moist curing will give a 28-day strength of about 65–70 per cent. that of the standard 28-day specimen in the same condition (wet or dry) at test. Concrete dried after 14 days will develop about 88 per cent. of the standard.

(2) Intermittent wetting or sprinkling is not as effective as continuous moist curing, unless the wetting be thorough enough to keep the concrete moist during the interval between wettings. Whenever concrete dries, curing (i.e. gain in strength) almost ceases. It resumes at a diminished rate when moisture is again available.

(3) Early drying is probably permanently detrimental to the concrete, even if it be subsequently subjected to standard moist conditions. For instance, a specimen that was in air after the first day and then immersed at the age of one month had acquired a strength of about 98 per cent. of the 28-day standard at the end of 3 months. This illustrates the diminished rate of gain.

(4) Early drying is permanently and extremely detrimental to the concrete if it remain in the dried state. Concrete that is not wetted will never develop a strength appreciably above what it has at 5, 6, or 7 days (when enough of the original mixing water has evaporated to halt further curing action).

(5) With alternate saturation and drying the curing will be equivalent to a uniformly moist condition if the drying is not too prolonged—see (2). If

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* "The Effect of Varied Curing Conditions upon the Compressive Strength of Mortars and Concretes."—H. J. Gilkey, *Proc. Am. Conc. Inst.*, Vol. 22, p. 395, 1926.

drying is complete between saturations, strength will be less than that of moist-cured concrete, but not as low as concrete cured dry. This statement takes no account of some situations in which alternate swelling and shrinking might damage the concrete by violent internal stress fluctuations, etc.

(6) The difference in strength between concrete cured moist and concrete cured dry is enough to be of great practical importance. Concrete which is moist cured will develop from 1½ to 3 times the 28-day strength of dry-cured concrete, if both be in the same condition at test. The ratio becomes greater for greater ages.

(7) Concrete cured moist but dried out at test is stronger than the same concrete tested wet, in the same way that brick or porous stone is stronger when dry than when saturated. When re-soaked the concrete resumes its former wet strength. The strength gain from drying out will vary from 10 to 40 per cent., depending upon the mixture, the degree of drying, etc. A good average value for typical concrete mixtures under average conditions may be taken conservatively as 15 or 20 per cent. For wet mixtures (high water ratio) it may be as low as 10 per cent.

The mere mechanical process of drying out, as previously stated, increases the strength from 10 per cent. to 40 per cent. This is not a permanent gain, however. The same concrete when again wetted would have only the strength of wet-tested concrete. Thus a specimen wet at test is always potentially as strong as a similar specimen tested dry and giving a much higher test strength, while one tested dry is potentially as weak as the wet-tested one. Thus we have an apparent contradiction, viz., that the ideal curing condition is that of moist storage for the longest possible time, while the greatest strength is attained by removal from storage and drying out. Doubtless it is a fair analogy to liken saturated concrete to saturated stone or brick, either of which will test much weaker while wet than dry. (The analogy must end here, since neither the stone nor the brick sets or cures.)

Thus true curing produces permanent improvement in strength, while mere drying produces a temporary increase, present only so long as the dry condition exists. This substantial increase in strength attainable by drying prior to test has been recognised and demonstrated by several authorities. It is not certain that it has always been clear that the gain is purely a mechanical one and that a dried out concrete removed from wet storage at an age of, say, 15 or 20 days, and giving an ultimate strength 20 per cent. above that of a standard 28-day companion specimen tested wet, is potentially about 15 per cent. weaker than the 28-day specimen. The 28-day standard specimen has had the benefit of a week or more additional wet curing and if allowed to dry out before test would develop a strength of some 135 per cent. of its own wet strength instead of the 120 per cent. given by the specimen removed at 15 or 20 days. These figures will, of course, vary with the mixture, the dryness of the air, mass or size of specimen, etc., but the general situation holds true.

(8) Moist storage is more essential to wet-mixed concrete than to drier mixes.

(9) Mixes of different richness respond in the same way to different curing methods, but probably not to the same extent. These tests do not indicate clearly which way the trend lies, as there is no series in which cement content was the only variable.

(10) There is no essential difference in manner between the curing of concretes and mortars, but some of the results appear to indicate quite a difference in degree. Mortars appear to have higher percentage fluctuations of strength, moisture content, etc., than do concretes. This evidence is complicated, however, by the presence of two variables. The mortar and concrete specimens were not usually of the same size. (Mortars 2 in. by 4 in.; concretes 6 in. by 12 in.)

(11) For a small body of concrete with relatively large surface area, serious damage from drying out is to be expected. The response to an unfavourable environment is much more rapid and complete for small than for large specimens. The response to the addition of moisture is, practically speaking, about equal in the two cases. Even a large mass of concrete soaks up moisture quite rapidly until nearly satisfied.

(12) Special precautions should be taken in constructional work to avoid drying out, especially if heat be used to prevent freezing. It is probably true that concrete in buildings (especially those erected in cold weather) is much weaker than the tests on moist-cured samples indicate. It is very important that precautions be taken to supply plenty of moisture for curing.

(13) The rate of absorption is always rapid until saturation point is nearly reached. The rate of evaporation varies with the environment, but it is always much slower than the rate of absorption. For two specimens of different sizes the difference in absorption rates is not important because they are both relatively rapid, but there is a distinct difference in the evaporation rates, the smaller specimens having the greater rate.

(14) Autogenous healing will take place as long as moisture is present. It ceases whenever the concrete dries out, but will be resumed upon subsequent wetting.

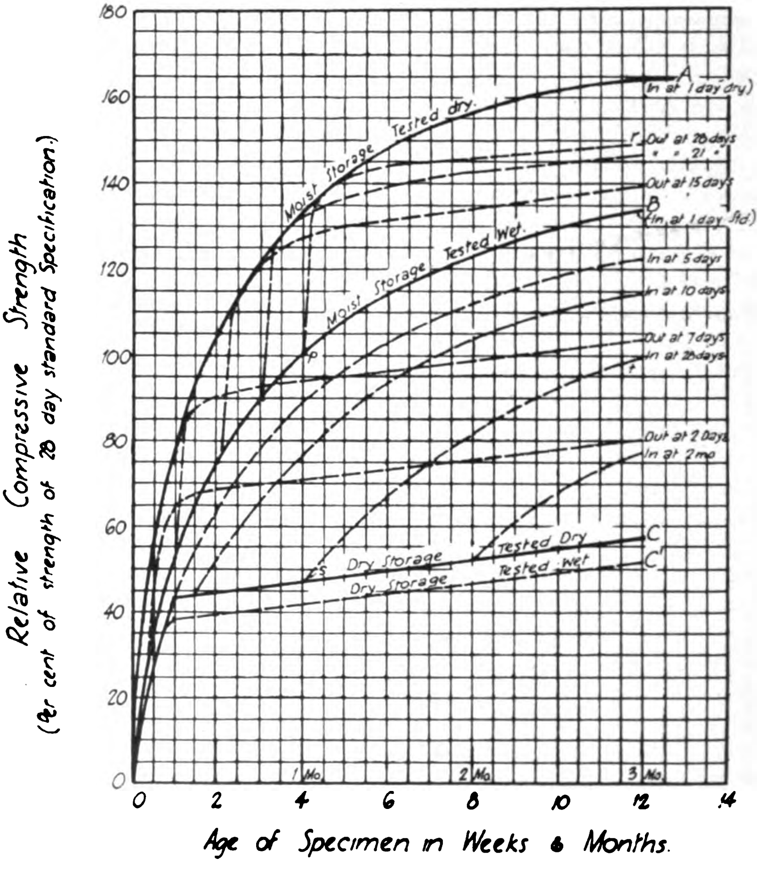
(15) No rule for the relation between 7-day and 28-day strengths will hold true for variable curing conditions since no fixed mathematical relation exists between 7-day and 28-day strength for different curing conditions. In case of dry-air curing, for example, the 7-day and 28-day strengths are almost equal. Slater excludes his rule for use in any cases except those of standard curing. A rule could doubtless be devised for any one condition of curing.

(16) The subject of curing can be condensed into a general law or basic principle that will enable the concrete practitioner to predict with reasonable accuracy the strength of an otherwise known concrete, under a variety of known or assumed curing conditions.

Universal Curing Diagram.

Conclusion (16) is illustrated on page 690. This figure seems to cover adequately the whole problem of water and the curing process. It is not expected or claimed that the percentages as determined by a mortar series in Colorado climate will correctly fit any particular concrete. But a similar chart can be made for any concrete that should serve as a universal curing diagram that will give reliable strength data for any probable "water and air" curing condition. The strength scale may be in terms of any standard strength or percentage.

In the early parts of the curve a slight difference in rate of drying will have a relatively large influence upon the location of the point of tangency between the drying curve and the upper envelope because the two curves are nearly parallel. Further on, the probable error is not great.



UNIVERSAL CURING DIAGRAM: ILLUSTRATIVE GRAPH FOR PREDICTING RELATIVE COMPRESSIVE STRENGTHS OF MORTARS AND CONCRETES AT ANY AGE AND FOR ANY COMBINATION OF WET AND DRY STORAGE.

56 34

In connection with this diagram it should be emphasised that the large excess strength along curve OA over that along the standard curve OB is not generally a usable gain because the differential simply represents a drying out process that is reversible. Any specimen of any strength along OB may have its strength increased to that of the point nearly directly above on OA curve by a few days of exposure to dry air. But any strength along OA will be reduced to the one below it on OB by a very short period of soaking.

All specimens removed from moulds at 1 day. Wet —— stored in water upon removal from mould (standard condition). Dry —— stored in air upon removal from mould. Out —— removed from moist to dry storage at the age indicated. In —— placed in moist storage at the age indicated.

The vertical scale will vary for different mixtures, etc. A single graph could be made to cover a wide range of usual mixtures without much error. The time scale could be extended by further experiment as far as desired. The present graph is based on mortars 1 : 2·5 by weight or 1 : 2·26 by loose volume. $\frac{W}{C} = 0{\cdot}70$.

Use of Graph.—*Questions.*—(1) What probable percentage of 28-day standard strength will be developed by this mortar in 2 weeks?

(*a*) If stored moist and tested wet?
(*b*) If stored moist and tested dry?
(*c*) If stored dry and tested dry?
(*d*) If stored dry and tested wet?
(2) What will be the percentage for 1, 2, and 3-month strengths?
(*a*) If removed from water at 28-days? (1) Tested dry? (2) Tested wet?
(*b*) If not placed in water until 28-days old? (1) Tested dry? (2) Tested wet?

Results.—(1) Reading values directly from curves B, A, C, and C' at two weeks: (*a*) 75; (*b*) 112; (*c*) 45; (*d*) 40.

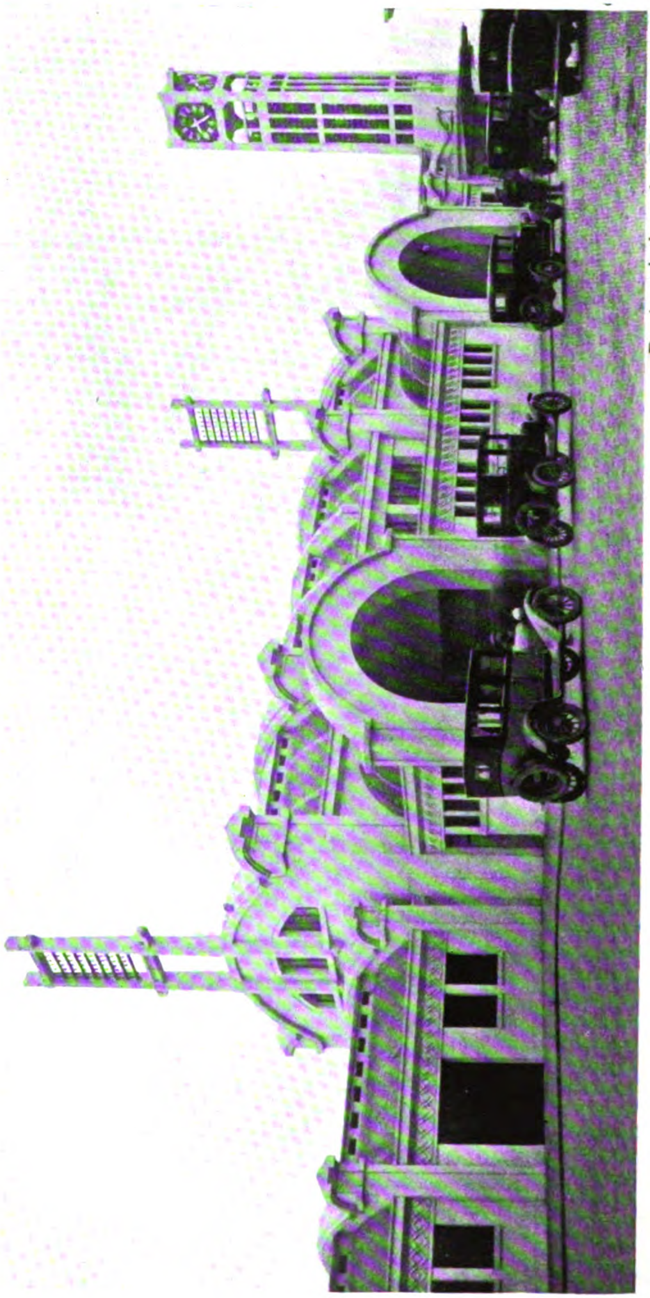
(2) (*a*) *opqr* represents percentage strengths: (1) 1-month test dry, 134; 2 months, 145; 3 months, 149. (2) 1 month test wet, 100; 2 months' wet $= 145 - pq$ or more accurately,

$$145 - \frac{pq + AB}{2} = 145 - 34 = 111;\ \text{3 months wet} = 149 - 30 = 119.$$

(*b*) *ost* represents percentage strengths:

(1) 1 month dry, 47; 2 months, 81; 3 months, 98.

(2) 1 month wet, $47 - CC' = 47 - 5 = 42$; 2 months wet, $81 - CC' = 76$; 3 months wet, $98 - 5 = 93$.



By permission of "The Times."

New Reinforced Concrete Railway Station at Lens.

Hooped Cast-Iron and Long-Span Arches.

At a recent meeting of the Institution of Structural Engineers, Mr. R. N. Stroyer, M.I.Mech.E., read a paper on the use of hooped cast-iron reinforcement for long-span arches, which has already been referred to at some length in this journal.

In the course of his paper the lecturer said, tracing the history of the arch it was interesting to note the influence the choice of building material available at any period had on the shape, dimensions and general appearance of the arch, and it afforded food for thought that in certain respects the pendulum had swung back to the solid type of arch with which the first beginning was made. The only materials at the disposal of the first arch builders were masonry or brickwork, and the only form of arch possible with brick or stone joined with mortar was a solid arch of such dimensions that the thickness at any point was sufficient to keep the stress line within the middle third, the material being unable to take tensile stresses. The solid arch held sway undisputed until the end of the eighteenth century when cast iron made its appearance as a bridge material. The comparatively light and elegant appearance of arches made in this material, combined with the greater latitude in span dimensions, due to the reduction of dead weight, gave rise to an extensive development in bridge construction with cast-iron arches with ribs and lattice work of a very pleasing description. The introduction of wrought iron and steel gave the bridge builder a material equally good in compression and tension and therefore ideal for constructional purposes, and the advent of another material that would stand both tension and compression, reinforced concrete, to a certain extent turned the development towards the solid arch, and gave an impulse to the revival of this type of arch.

At present steel and reinforced concrete were dividing the field between them, each having certain advantages and drawbacks, but, without going into the usual arguments as to cost, permanence,

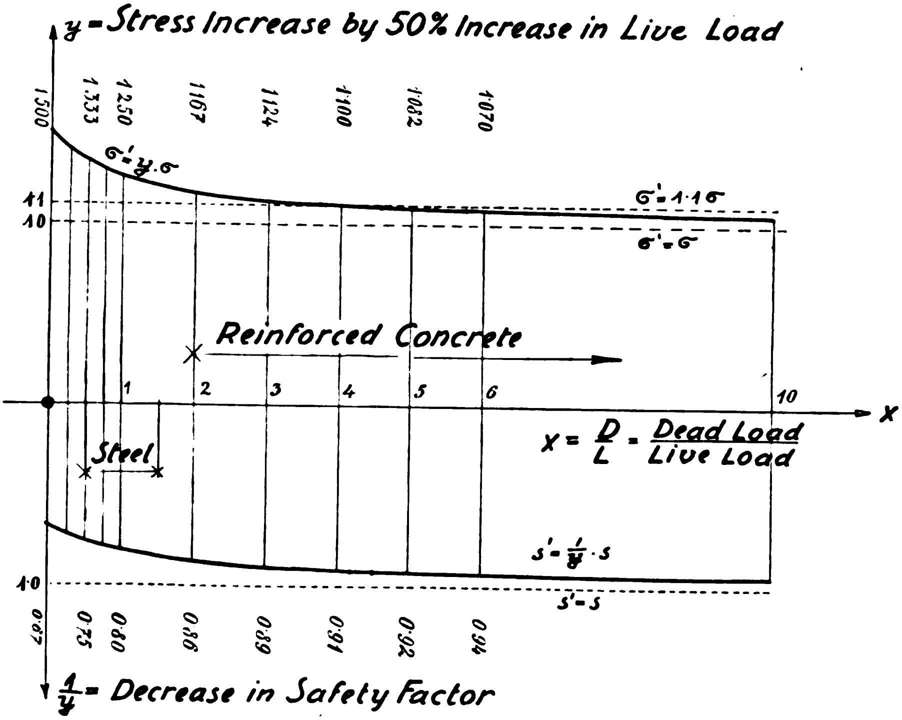


Fig. 1.

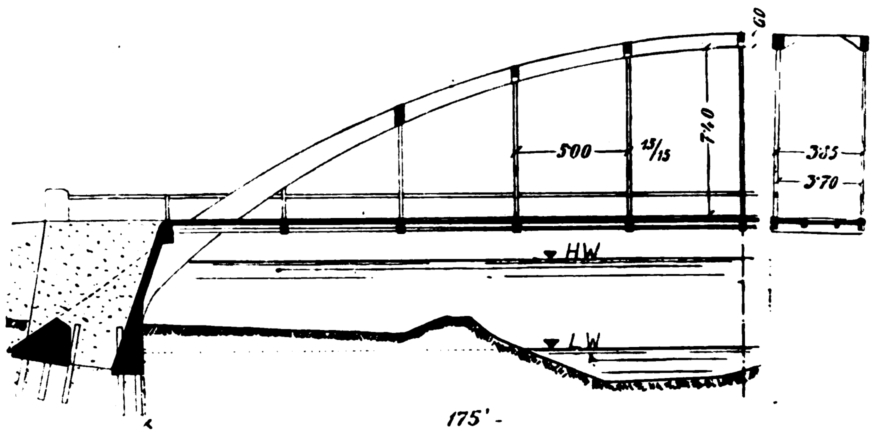


Fig. 2.

upkeep, etc., there was one aspect which was sometimes lost sight of in regard to the dead load of the structure. While it was true that for very long spans steel had the advantage of a comparatively small dead load, it was nevertheless a fact that for spans where reinforced concrete could compete in cost with steel the greater dead load of the former was an asset often overlooked, a very valuable asset indeed. In view of the increase in the volume of traffic from year to year, a contingency that had to be faced in any new bridge construction was the probable increase in live load in the course of a few years. If this increase in live load meant a considerable increase of stresses in the bridge a reconstruction might be necessary, and that was where the greater dead load of reinforced concrete was of value.

A graph would illustrate the circumstances better than words and Fig. 1 showed the relation between a 50 per cent. live load increase and the corresponding stress increases in bridges having various ratios D/L of dead load to live load. For a theoretical dead load of zero the stress increase would be 50 per cent., and the corresponding decrease in factor of safety 33 per cent.; for steel structures where D/L was between ½ and 1½ the stress increase was between 33 per cent. and 20 per cent., and the corresponding decrease in factor of safety as 25 per cent. to 17 per cent., and only when D/L became higher than 2 the effect of the live load increase became small enough to neglect. From *Fig.* 1 might be found the D/L required for the condition that the stress increase must not exceed 10 per cent.—a dead load of 4 times the live load secured this. A 10 per cent. increase in a reinforced concrete arch would not mean any danger, especially as the time-factor had probably increased the strength of the material, but a 25 per cent. increase in a steel structure might mean reconstruction. For the latter structure to be virtually comparable with the reinforced concrete arch it should really have a factor of safety correspondingly higher.

While the greater dead load of reinforced concrete might thus be an advantage for what might be termed medium spans, it certainly imposed a limit on the development of the long-span arch in reinforced concrete, for various reasons. The cost of the foundations became a factor of importance, and the falsework for the arch might assume such proportions that this item alone might turn the scale against reinforced concrete.

In order to overcome these difficulties designers had turned their attention in two directions; first, cutting down the dead load by splitting up the arch ring into ribs, flanges and lattice work; and second, by making use of a self-supporting system of reinforcement from which the falsework might be slung. The latter system was originated by Professor

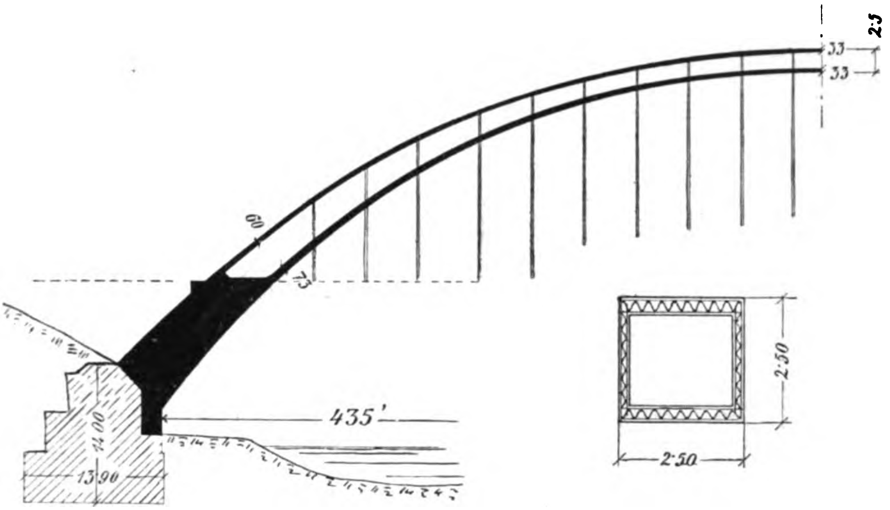


Fig. 3.

Melan, and had found widespread use in cases where the temporary staging and falsework would otherwise have put reinforced concrete out of court.

In spite of these remedies it might be said to be characteristic of the present situation that reinforced concrete arches of 300-ft.–600-ft. span were spoken of as curiosities rather than commonplaces. A good many of the older engineers preferred steel because they were more familiar with that material and often looked with suspicion on reinforced concrete arches, especially with fixed ends, a condition which was sometimes thought to require something in the way of rock foundations, whereas fixity could be obtained under very poor foundation conditions. An example was an arch of 175-ft. span over the River Main (*Fig.* 2), where timber piles provided all that was required. Warrington Bridge, of 134-ft. span, was another example of a fixed end arch on piled foundations.

Among the important large span arches built during recent years might be mentioned a 300-ft. span arch over the Tiber in Rome, designed by Hennebique before the war as a kind of fixed end cantilevers carrying the middle portion. In America there was the 370-ft. span arch over the Mississippi, near Minneapolis, whereas a 400-ft. span might be found in France at St. Pierre du Vauvray (*Fig.* 3). In the latter could be seen how the designer had lightened the arch ring by splitting it up into a hollow tube, while a smaller example (*Fig.* 4) represented another method of lightening a 125-ft. arch, at

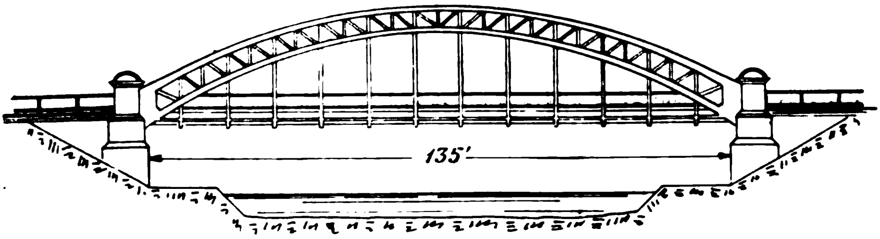


Fig. 4

Aubigny-au-Bac, where the designer, M. Lossier, had introduced lattice work connection between the top and bottom boom.

The idea of forming the arch ring as a hollow tube had been followed by M. Freysinnet in a second large-span bridge now under execution over the river Elorn, near Brest, where there were three spans of about 600 ft. For further particulars of this structure see *Concrete and Constructional Engineering*, December 1926.

No one could deny, however, that when they had to deal with such long spans the reinforced concrete arch began to show signs of heaviness. How the dead load began to be troublesome at large spans might be evidenced by a scheme submitted for a 525-ft. span at Arsta, near Stockholm, where the crown section of the arch ring was no less than 15 ft. by 6 ft., and would therefore require something rather elaborate in the way of falsework.

There was an economic limit to the span after which the increase in dead load overpowered the increase in carrying capacity; that might be said to be due to the fact that concrete in itself was a somewhat bulky compression medium, even making full allowance for the excellence of modern cement, the increase in strength by hooping, etc. Even if they succeeded in increasing the working stress of concrete up to double what was now allowed by the usual regulations, and in addition made use of compression steel, they still suffered from working with too bulky a compression medium. If the compression strength of the concrete could be intensified, the dimensions of arches, which were, of course, mainly compression members, could be cut down and the designer freed from the millstone of dead load.

It was with a view to attaining this end that another compression reinforcement had been introduced and tried, in the form of cast iron, and its use had resulted in the development of many striking and novel features. The use of cast-iron reinforcement was not new—arch bridges were executed in that way more than a dozen years ago—but he did not think anything had been done in this country with cast-iron reinforcement. Cast-iron was first introduced as reinforcement by Dr. Emperger, of Vienna. During his experiments and tests he had two main principles in mind as the basis of his new departure, one the fact that cast iron was an ideal compression medium, stronger than steel and cheaper in cost, the other was the postulate that the co-operation of concrete and cast iron was a far more intimate one than that suggested by the usual factor $m = 15$, and that therefore cast iron could be utilised far better than this assumption would warrant.

As the result of a great number of tests carried out on concrete and cast iron, Dr. Emperger had established that in most cases it was safe to reckon $m = 40$. With a concrete stress of 600 lbs. per sq. in., he would thus have a cast-iron stress of 10 tons per sq. in., which, of course, would utilise the cast-iron section fairly well, but not up to the economic limit, in view of the fact that cast iron might be stressed to 55–60 tons per sq. in. ultimate. A certain amount of hooping was therefore introduced, which served two purposes: first, to increase the compression strength of the concrete; and second, to reduce the brittleness of the cast iron. The hooping produced an external pressure on the concrete and the cast iron, comparable with a liquid pressure, which altered the properties of the hooped members, especially in regard to brittleness, so much so that they could actually bend without breaking.

It would be seen that with the high utilisation of the cast-iron reinforcement the latter played a very much greater part in the total compression capacity of the member than in ordinary reinforced concrete, and it was almost necessary to conceive the former reinforcement in other terms than the usually accepted ones; in reinforced concrete compression members the concrete was the main thing, and the small percentage of steel increased the compression capacity only slightly, whereas with this other type of reinforcement the cast iron was made to carry the main portion of the load and was reinforced by one-fortieth of the concrete area. The higher m was taken the smaller was the part played by the concrete, and the sooner was the limit reached for the full utilisation of the cast iron.

The maximum load that could be carried by a given section of cast iron was a constant, and had no relation to the value of *m*, which was variable because the concrete varied. With a smaller *m* the total compression capacity was greater and the concrete should therefore be hooped in such a way that it might be compressed sufficiently to allow the cast iron to develop the high compression stress desired.

By numerous tests on hooped cast iron, stressed not only in compression but in combined bending and compression, it had been found that whereas for low stresses *m* might have a small value, the latter rose with increasing load, and might attain a value of about 50 at breaking load, so that with increasing load the cast iron took over a larger proportion and relieved the concrete correspondingly.

When dealing with eccentric loads, as in arches, the fact that the cast-iron reinforcement was butt jointed, and therefore unable to take tension, might appear at first sight to be a disadvantage, but was really a help to the designer, inasmuch as the inertia moment of the section was influenced by the predominating cast iron in compression, and with increasing stresses the centre of gravity was gradually moved towards the eccentricity, decreasing the latter, and thereby also any tension stresses, so that it was comparatively easy to keep the forces within the kernel of the section and eliminate wholly or partly the tension stresses.

Combined bending and compression tests had demonstrated these circumstances very clearly. The February and September numbers of *Concrete and Constructional Engineering* for 1926 contained reports of two tests carried out at the instance of the Austrian building authorities to satisfy them as to the safety of this method of construction. There, like here, they had reinforced concrete regulations which did not provide for cast iron as reinforcement, but there was a redeeming paragraph in the Austrian regulations which provided for satisfying the requirements of the authorities by tests under actual working conditions of any part of the structure the design of which did not come within the scope of the regulations, the test load being three times the working load.

The difficulty in introducing this new combination of materials had been, that it was only for very heavy columns or very long-span arches that its advantages showed up—for smaller loadings reinforced concrete came out as cheap, and was, of course, more familiar to most engineers, so that instead of beginning at the bottom with light columns and small arches, hooped cast iron had to make its way by engineers having the courage of their convictions and using it straight away on large spans or heavy columns where they reaped the benefit of a very considerable saving in dimensions and dead load, so much so that there was almost the same relation between hooped cast iron and reinforced concrete as between the latter and plain concrete. If, for instance, an 18-in. column in plain concrete could take 27 tons, the 15-in. core in a reinforced concrete column of best quality could take 81 tons if hooped with the L.C.C. regulation volume, and each 1 per cent. of longitudinal steel would add about 8 tons carrying capacity, so that with 4 per cent. additional steel the carrying capacity was 115 tons, whereas each per cent. of cast iron was capable of carrying 31 tons. A 4 per cent. reinforcement would therefore give 207 tons, or nearly twice the carrying capacity of the reinforced concrete column.

Whereas there was an economic limit to employing compression steel, cast iron might be used in far higher percentages, and 10 per cent. was not unusual in column construction in order to reduce the scantlings; with this percentage the cast iron would be capable of carrying 315 tons, and the total capacity would be 396 tons. The essential difference between the two columns was seen from this example; in the last case the cast iron did 80 per cent. of the work, whereas in an ordinary reinforced concrete column, where the percentage would probably not exceed 2, the concrete did 75 per cent. of the work. The hooped cast iron approached the steel structure in its natural properties, its weight and its slenderness. The steel bridge shown in *Fig.* 5 might be compared with *Fig.* 6 which gave the general proportions of its counterpart in hooped cast iron—the arch of the latter was if anything more slender than the steel arch, and it would be noticed that no cross bracing was necessary. A still better example of the slenderness of a hooped cast-iron arch of 175-ft. span was given in *Fig.* 7; that

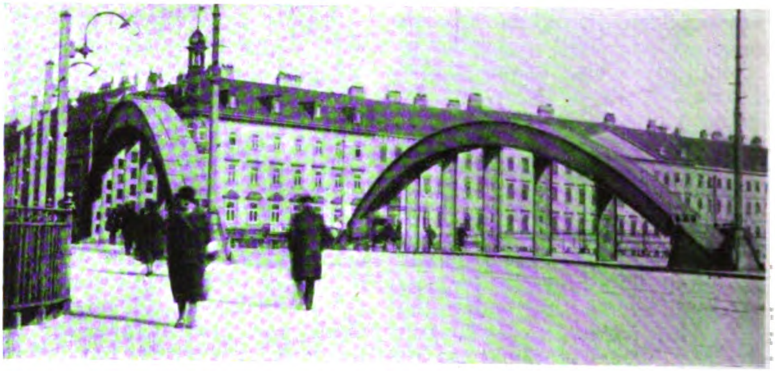


Fig. 5.

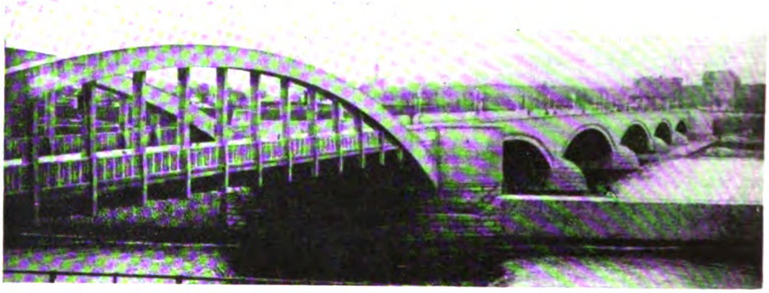


Fig. 6.

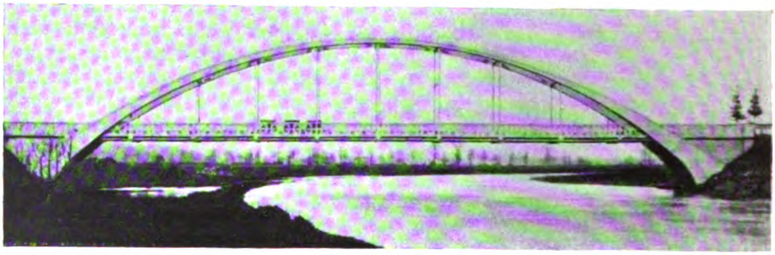


Fig. 7.

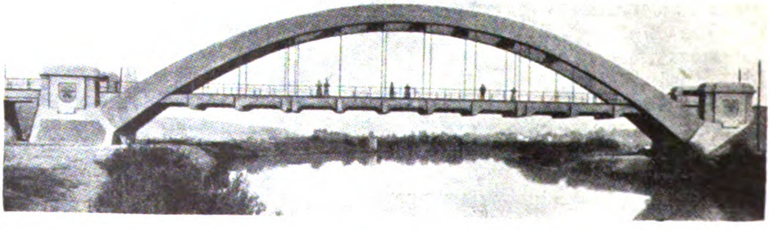


Fig. 8.

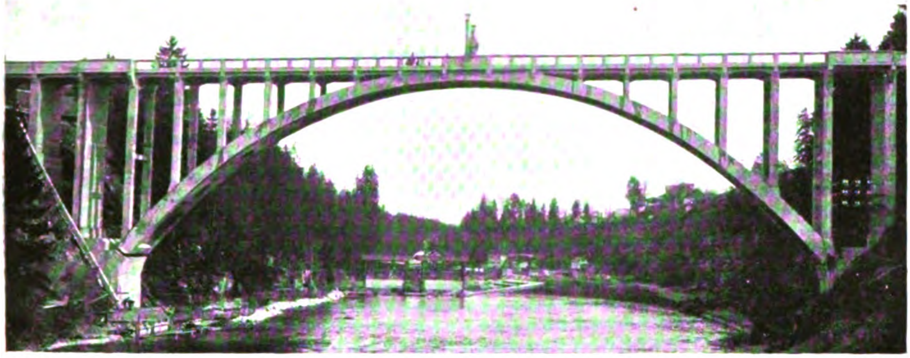


Fig. 9.

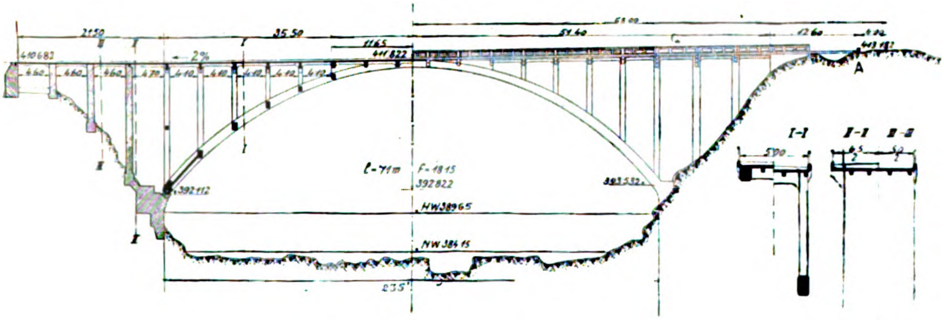


Fig. 10.

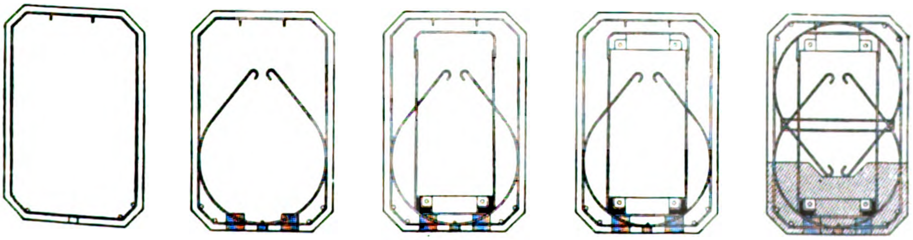


Fig. 11.

Fig. 12.

full use was made of fixity was best shown by the slim crown and the comparatively deeper springing. When comparing this with a view of an ordinary reinforced concrete railway bridge of exactly the same span (*Fig.* 8), the great difference in slenderness would be apparent; although he (the lecturer) was responsible for the design of this bridge he did not mind admitting that the comparison was odious, but it was built before hooped cast iron was used for this kind of work, and it had to satisfy certain conditions as to tensile stresses in the concrete.

For smaller spans where admittedly the use of hooped cast iron showed no economic advantage, there was not much difference in the proportions between the former and reinforced concrete, but for spans over 200 ft. hooped cast iron began to show an advantage. *Fig.* 9

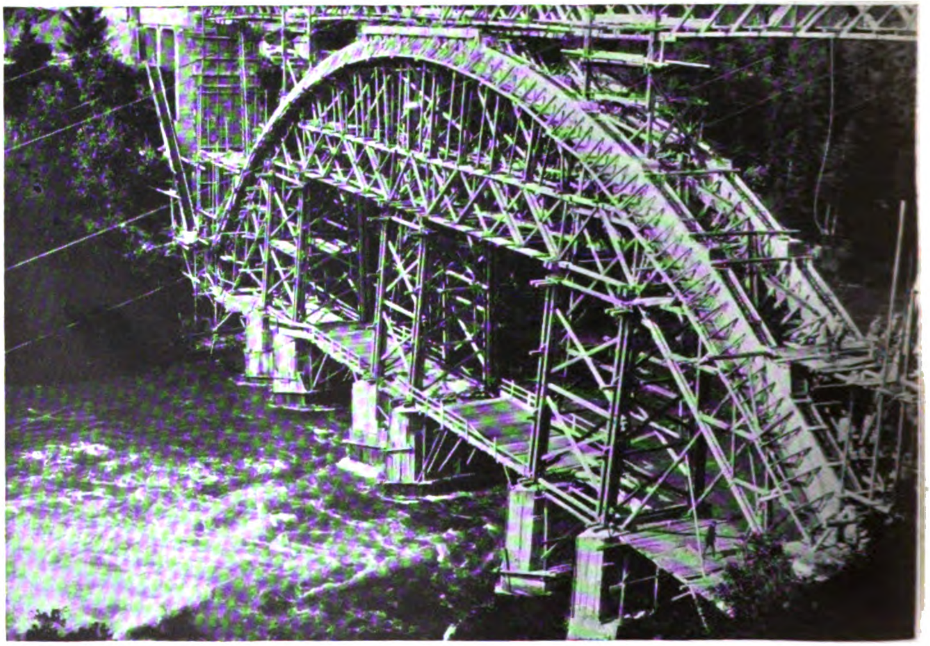


Fig. 13.

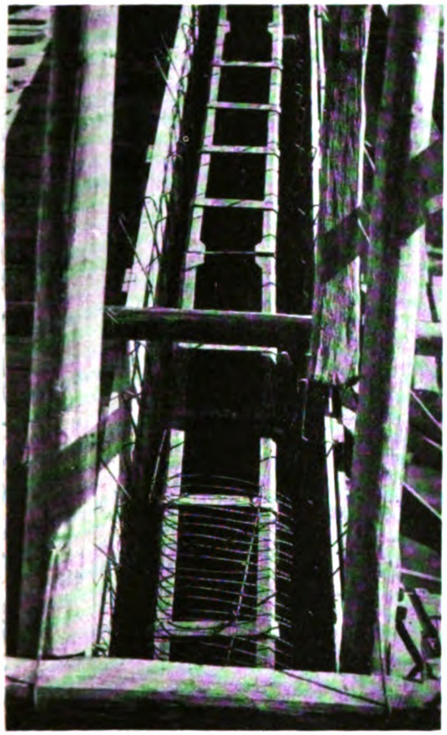


Fig. 14.

gave a view of a 235-ft. span arch recently completed at Trauen, in Austria. *Fig.* 10 was a section and elevation; *Fig.* 11 gave some reinforcing details where the cast-iron reinforcement and the hooping were shown, together with the small amount of tensional steel required. The reinforcement was shown temporarily assembled in the foundry before dispatch (*Fig.* 12), and in position in the mould in *Fig.* 13, which gave a good idea of the extent of falsework for even such a light bridge as that. The two ribs were clearly seen with the reinforcement, of which a close view was given in *Fig.* 14, where the cast iron and its hooping were seen. *Fig.* 15 showed an arch of 250 ft. span over the river Spree, also in hooped cast iron.

Fig. 16 gave the dimensions of a scheme for a 650-ft. span arch over the Danube where the arch consisted of two sets of twin ribs, each reinforced with sectional steel in the form of a self-supporting arch girder from which the centering might be suspended, and supplemented with cast iron hooped on Dr. Emperger's method. The individual ribs were about 3 ft. wide by 8 ft. deep. The general arrangement for the execution of the scheme was shown in *Fig.* 17, where the suspension of the arch girders and the transport cables were seen.

With a view to training the information available on the subject into official channels, and to prove definitely the various formulæ put forward by Dr. Emperger, the Austrian Concrete Committee had caused a number of tests on columns to be carried out under official supervision, mainly with a view to giving a clear insight into the effect of hooping, both of concrete and of cast iron. Those tests were a continuation of a series that were undertaken during 1906–10, and

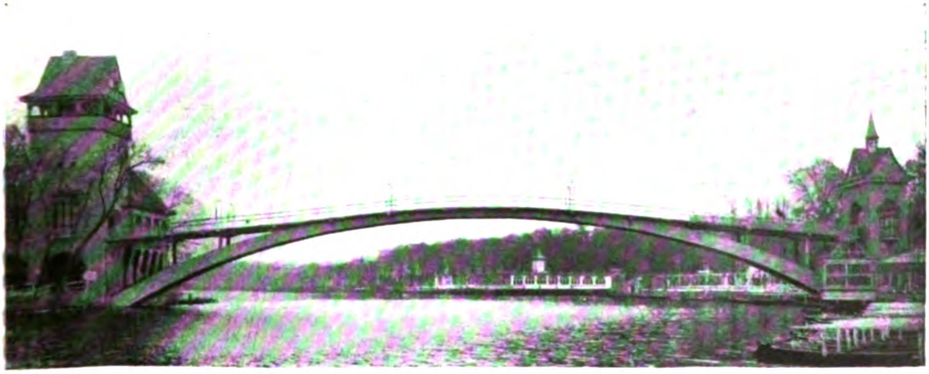


Fig. 15.

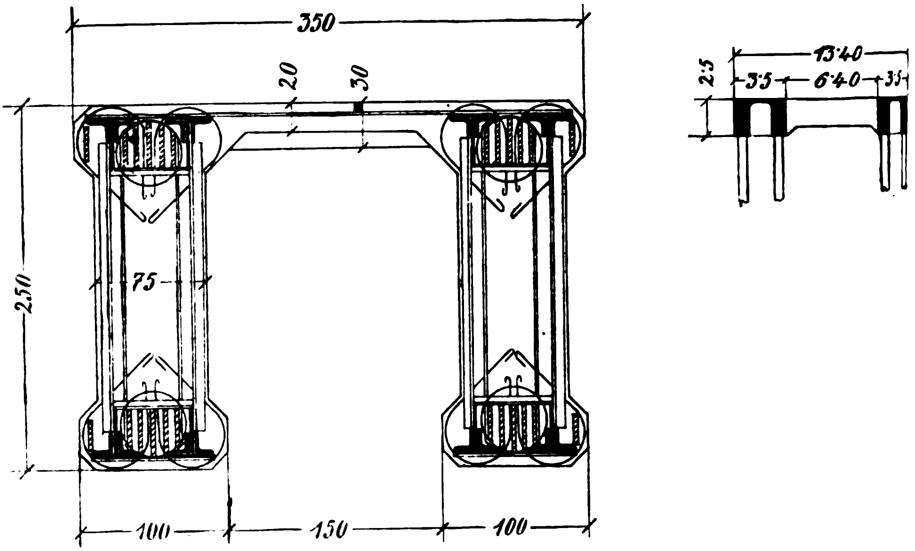


Fig. 16.

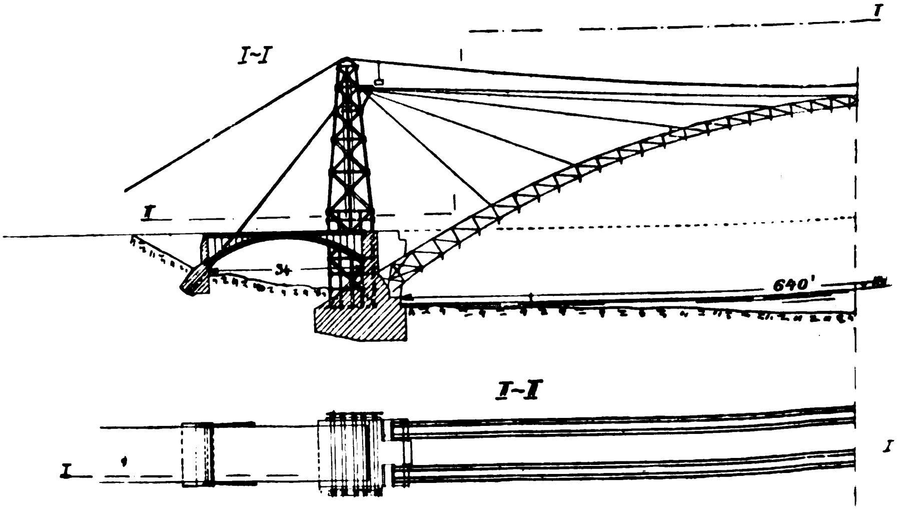


Fig. 17.

dealt with the two important questions in column construction, the hooping and the longitudinal reinforcement. The report of the Committee had just been published, and as the result of about 50 tests arrived at some important conclusions.

Since Considère invented and developed hooping the effect of this method of reinforcement had been taken into account and embodied in most concrete regulations, the effect being most frequently expressed as a function of the quality of the concrete and the volume of the hooping, whereas the quality of the hooping was not taken into consideration. The effect, according to the latest report, was, however, found to be practically independent of the quality of the concrete, but depending very greatly on the quality of the hooping material. The recommendations of the committee were based upon a series of interesting observations and measurements of the lateral expansion of the concrete under pressure and the yielding of the hooping steel. With one of the new formulæ in the report it was even possible to determine the quality of the hooping wire in the earlier tests, which was not investigated at the time.

With regard to the question of longitudinal reinforcement, the new tests proved that the usual limit of 3 per cent. steel laid down in many regulations might be substantially increased, and that even at a percentage of 10 the steel acted together with the concrete in the required manner. This was of importance in view of the use made of sectional steel cased in concrete, and while at present the building regulations in this country did not recognise this collaboration of concrete and steel, there was sufficient material at hand in the way of numerous tests to prove that it was quite safe to assume that collaboration. Dr. Emperger showed in 1909 that a steel column built up of angles and lattice bracing was very considerably strengthened by the concrete casing, and with regard to recent experiments on this question he referred to the reports by Mr. E. S. Andrews in *Concrete and Constructional Engineering* for August, 1923, and January, 1924, and by Dr. Oscar Faber in the same journal for December, 1924, the latter report dealing with Col. Mitchell Moncrieff's experiment on columns. The latter was interesting in more than one way, inasmuch as the actual distribution of the load between concrete and steel was measured, and this gave a ratio between the steel and the concrete stress of about 20 in one case and 30 in the other.

In continuation of the Austrian tests with steel reinforcement, similar experiments were made with columns reinforced with 5 per cent. to 10 per cent. of cast iron, and it was shown that the cast iron sections increased the carrying capacity

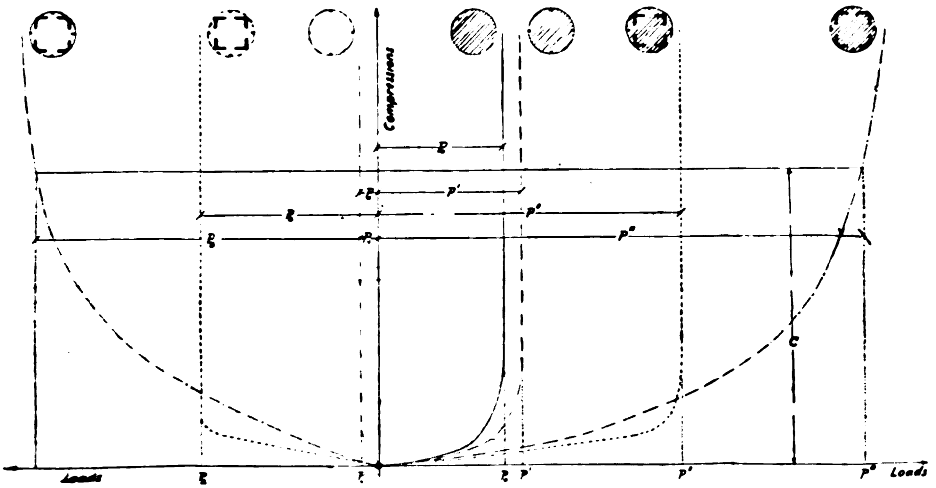


Fig. 18.

of the column according to the formula proposed by Dr. Emperger as the "law of addition." and also that a modular ratio of 15 did not apply. *Fig.* 18 illustrated the "law of addition," according to which the force necessary to compress a compound section a certain amount was the sum of the forces necessary to compress each member of the section the same amount. The compression deformation was shown as ordinates, the forces as abscissæ, and for each member of a compound section the compression curve was shown, giving the corresponding values of forces and deformations. Thus a deformation C required the force P_0 in the case of a concrete section, whereas a 1 per cent. mild steel reinforcement required the force P_1, and the combination of the two required the force $P' = P_0 + P_1$. P_2 was the force required to compress a 10 per cent. mild steel reinforcement and P_3 the force for a 9 per cent. cast-iron reinforcement whereas P'' and P''' were the forces required respectively for the combinations of concrete and 10 per cent mild steel or $P_0 + P_2$—and concrete and 1 per cent mild steel and 9 per cent. cast iron, or $P_0 + P_1 + P_3$.

The observations made during the compression tests fully corroborated this. Six of the columns were numbered 7, 8 & 9 in one group and 21, 23 and 24 in another

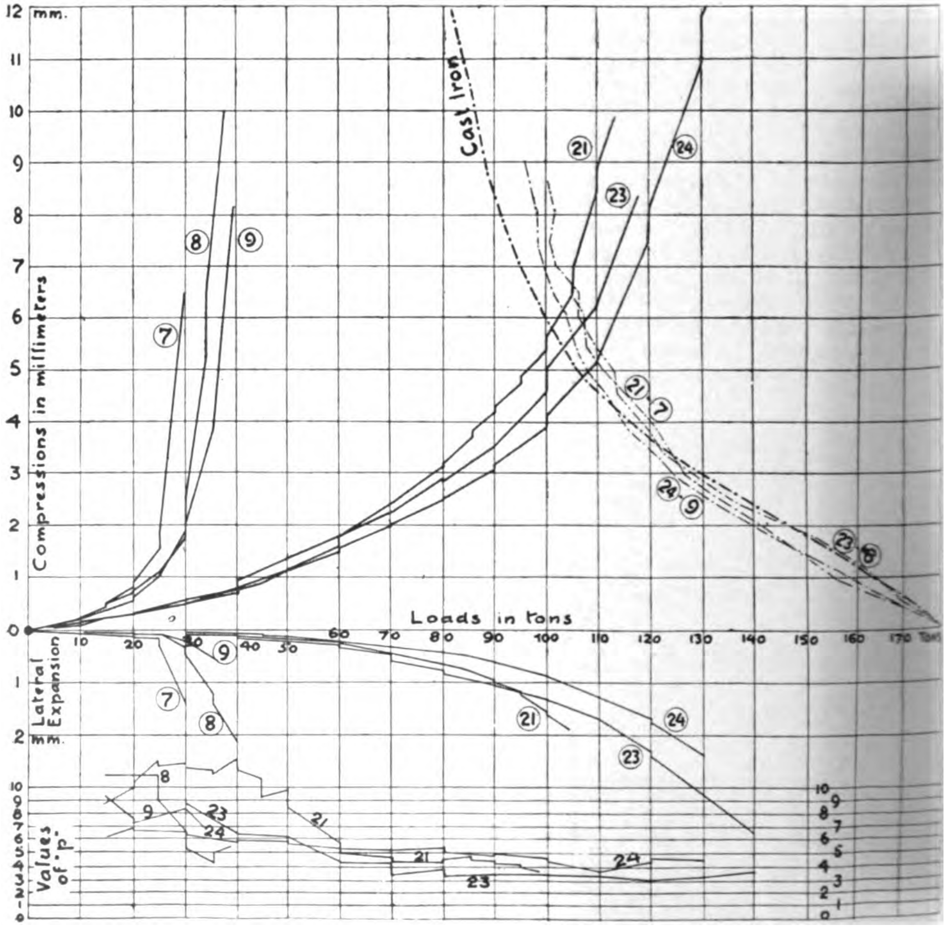


Fig. 19.

group, the two groups being identical except for the provision of cast-iron reinforcement in the last group. Columns 7, 8 and 9 were circular with the same longitudinal mild steel reinforcement consisting of four round bars, and hooped with ½ per cent., 1 per cent., and 2 per cent. respectively in high tensile wire. Columns 21, 23 and 24 were identical, but had each a 10 per cent. additional cast-iron reinforcement consisting of four bars of x section.

Fig. 19 showed the plotting of the compression curves, the first group, (7-8-9) being shown on the left, where the compression in millimetres was plotted as ordinates and the force required for the compression, in tons, as abscissæ. The ultimate loads on 7, 8 and 9 were 31 tons, 54 tons and 80 tons respectively, of which the concrete alone carried about 17 tons and the longitudinal mild steel reinforcement about 8 tons in each case. The effect of the hooping was an increase of 6 tons, 29 tons, and 55 tons in the three cases, the latter with an expenditure of 2 per cent. high tensile steel. In passing, it might be mentioned that a mild steel hooping of 2.3 per cent. in one of the other tests, gave an increase of 13 tons only. The next group, (21-23-24) was shown further to the right, the ultimate loads in this case being 126 tons, 174 tons and 177 tons respectively, the increase being due to the only new factor, the cast iron.

The observation curves plotted showed a fairly uniform course of the stress-strain

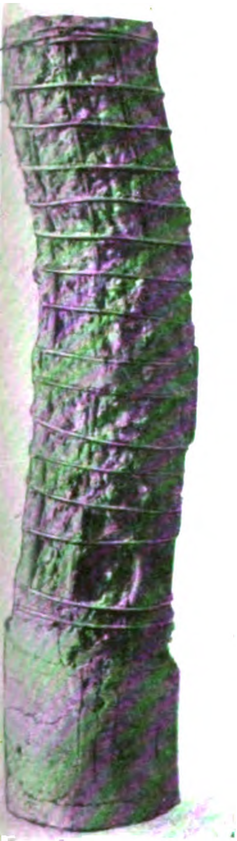


Fig. 20.

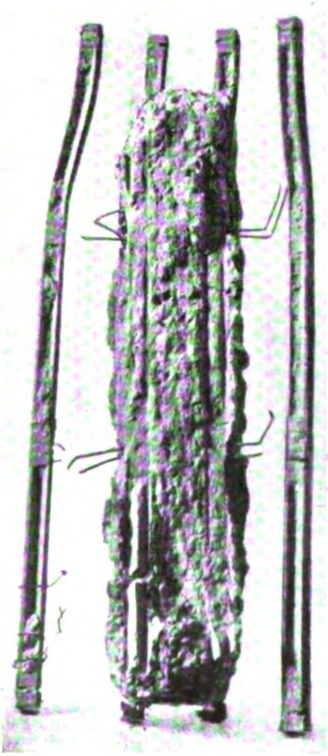


Fig. 21.

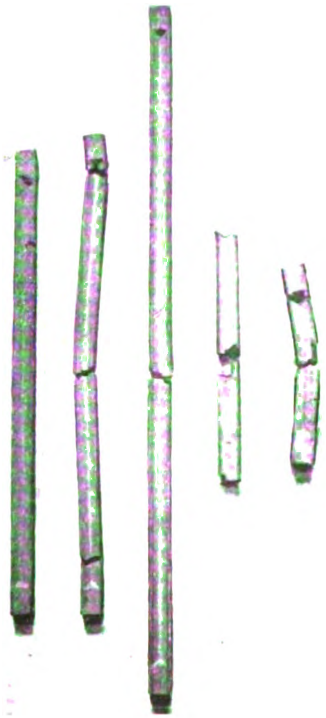


Fig. 22.

line, but the most interesting fact in this connection was the plotting of the cast-iron stress-strain line on the right-hand side of the figure, found during an independent test, and together with it the three curves found as difference between the two groups. The three curves approached very closely the actual cast-iron line, allowing for inaccuracies in the observation figures. Below the abscissæ line the corresponding lateral expansions were plotted, and it was interesting to see how, with the introduction of the cast-iron member, the course of the curves became much more regular. Finally the ratio between longitudinal and lateral deformation was plotted at the bottom of the figure, and it would be seen that the lines converged towards the value 4.

Throughout the tests it became apparent that the function of the cast iron, apart from load-carrying, was that of an equalising agent, making the course of the plotted stress-strain lines more uniform. The introduction of the cast iron produced similar phenomena to those occurring in the tension zone of concrete by the introduction of tension steel. The latter did not alter the tensile strength of the concrete, but distributed the extension along the whole of its length so that local overstrain and consequent cracks were avoided. Similarly, the action of a high compressive member in a concrete column consisted in equalising the irregularities in the latter. When, during compression, the ultimate strength of the concrete itself was being approached, the irregularities began to show themselves, and, in the case of ordinary hooped concrete, generally resulted in one-sided deformation, when whipping of the column and buckling soon supervened.

The cast iron decreased and distributed the great deformations occurring when the yield point of the concrete was exceeded, and which would otherwise lead to the destruction of the concrete. On the other hand, the cast iron, reinforced by the concrete and the hooping, developed novel properties when exposed to the heavy loads of the tests, and both the concrete and the cast iron were able to withstand quite considerable bending without breaking. Knowing cast iron as the brittle material it was, he thought they would agree that *Fig.* 20, showing Column No. 24, after the removal from the test press, was very remarkable indeed. The shape of the column spoke for itself, and they had to remember that inside that column were four ordinary cast-iron bars; when the concrete was

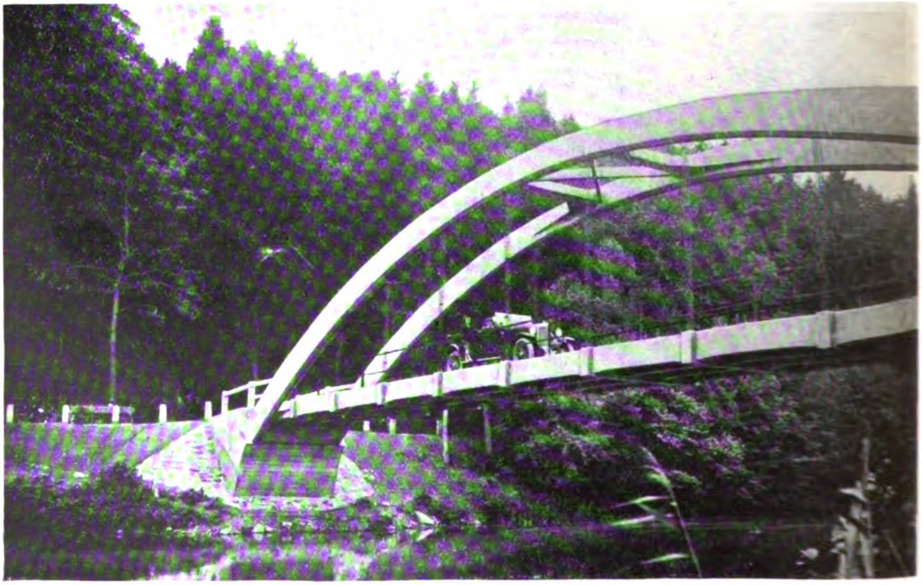


Fig. 23.

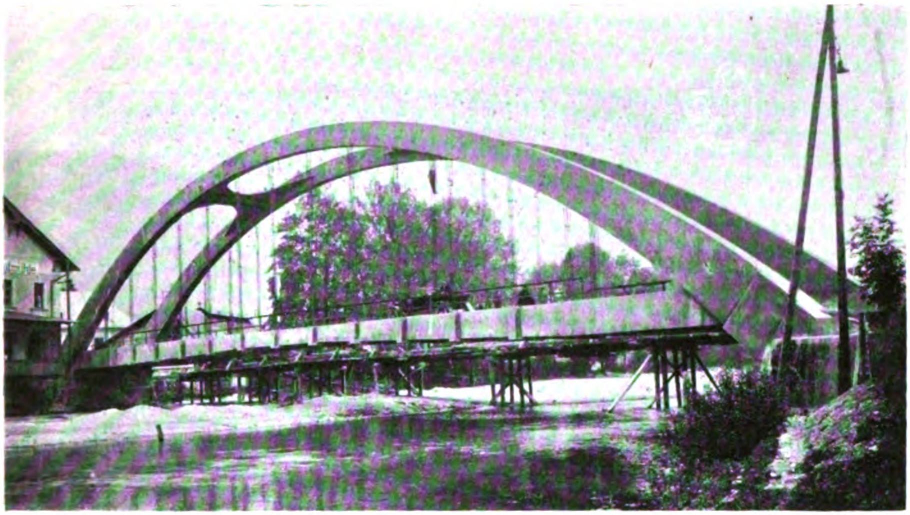


Fig. 24.

removed (and this operation by the way showed it to be quite good in spite of the enormous load it had been subject to), the cast-iron bars were seen to be unbroken (*Fig.* 21), but bent to the curve shown.

Fig. 22 showed some of the cast-iron bars used in some of the test columns without hooping, and showed that there was no bending in this case, but a sudden break.

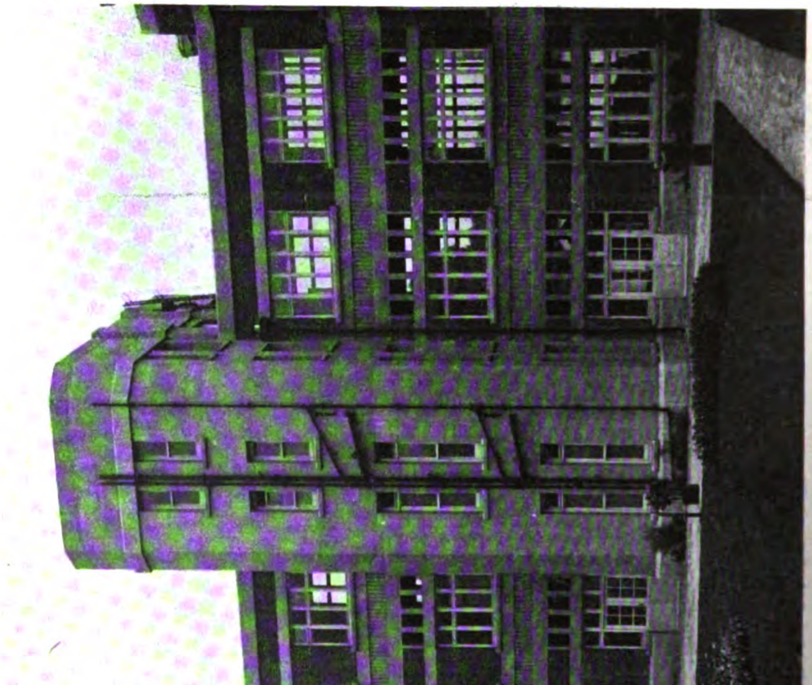
Figs. 23 and 24 showed photographs just obtained of two bridges in hooped cast iron, recently completed, the Purgstall Bridge of 115-ft. span, and the Scharnstein Bridge of 200-ft. span, both in Austria.

During the discussion which followed the paper, the lecturer pointed out that the figure *m* was not the modular ratio, but the ratio between the ultimate strengths of the materials in question; the elasticity modulus of cast iron was about 15 million lb. per sq. in., and that of concrete from 2 to 4 million lb. per sq. in., so that the high figures of 40 to 50 and even more could not be the modular ratios.

In reply to a question on the quality of the cast iron used, it was explained that it was not malleable, but a high-carbon hard grey iron.

The cement used was not aluminous, and could therefore not have generated any heat that might tend to anneal the cast iron; both the cement and the resulting concrete were, in fact, rather poor, the concrete having a cube strength of less than 2,000 lb. per sq. in.

The movement of the gravity centre of the section with increasing load was explained by the variation of *m* with the intensity of stress.



Extensions to the General Hospital, Lewisham. *(See p. 709.)*

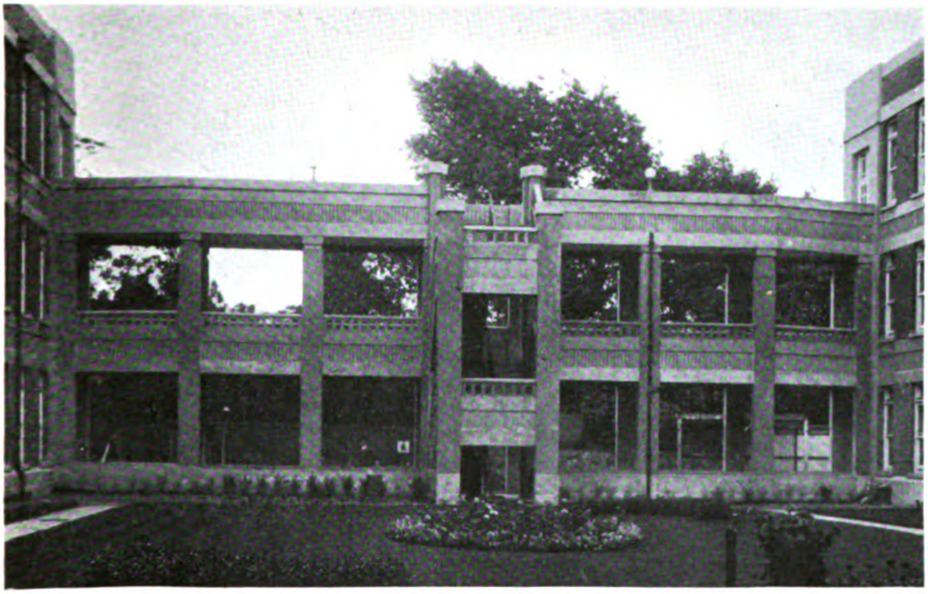
Surface Treatment of Concrete.

INTERESTING METHOD ADOPTED ON LARGE LONDON BUILDING.

THE extensions to Lewisham Hospital, illustrated herewith, are of particular interest owing to the method of surfacing adopted. The architects, Messrs. J. Douglass Mathews, Son & Ridley, while desiring something cheaper than natural stone or brick, but being averse to artificial substances, decided to express the concrete itself on the face of this reinforced concrete building.

The first steps taken were to re-design the elevation of the building, as it was recognised that the use of concrete must necessarily enforce different principles based upon the design and methods of construction of reinforced concrete. The whole façade, therefore, was designed perfectly flat, relieved by bold projecting bays utilised in the internal planning. Any monotonous flatness was relieved by bold horizontal stringcourses running the whole length of the building and decorated with fluting of shallow depth.

The next thing that had to be considered was the required texture, and the Trussed Concrete Steel Co., who were reinforced concrete engineers for the extensions, placed their resources at the disposal of the architects for the necessary experiments. In order to give the required contrast with the bricks for the window panels, it was thought that grey cement would be too dull, so it was decided to use white Portland cement. It was then necessary to select aggregates which would not contrast too severely with the cement but at the same time give a soft bright effect. After a very large number of tests a sample was selected containing white spar, Montsorrel granite, and blue granite, each in various grades. After further experiments it was decided to treat the surface with a wire brush so as to remove the cement scum and expose the aggregates in preference to any form of hammering or tooling.



Extensions to Lewisham General Hospital.

These experiments took a considerable time before sufficient certainty was attained to warrant a departure from ordinary methods. The plans had then reached such a stage that it was not possible to use the system, as was intended, with a reinforced concrete frame. Modifications were therefore made to render its application suitable for casting against a stock brick backing, leaving the full scheme to be carried out on the garage which was erected entirely in reinforced concrete. This garage, which is situated at the side of the hospital, has accommodation for 18 motor ambulances.

Reinforced Concrete Garage at Lewisham General Hospital.

The centering for the concrete was constructed in the ordinary way with the exception of that in contact with the face, which was erected in not more than 2-ft. lifts and temporary wedges were used to keep it 2 in. from the main reinforcement. Special care was taken with the face timbering to ensure it being cleanly wrought and truly fixed; 16-gauge steel plates 2 ft. 6 in. long and about 3 ft. wide were then placed edge to edge between the face shutter and the reinforcing steel and lightly wedged up to the latter, leaving a continuous space of about 1½ in. between the plate and the shutter. The special facing concrete was placed first and the ordinary structural concrete afterwards, keeping the latter always 6 in. below the level of the former. As the concretes were poured the steel plates were drawn vertically upwards, allowing the two wet mixtures to flow together but always keeping at least 3 in. of plate embedded in concrete to form a bottom fixing for subsequent lifts.

The secret of success in obtaining a good face lies in the accurate grading and even mixing of the facing concrete, in placing the concrete in a fairly dry state so that the larger stones do not tend to sink to the bottom, in even tamping in small lifts, and in removing any scum which may rise to the top at the completion of each 2-ft. lift, or particularly at the end of each day's work. The first layer after a stop should be placed slightly wetter and very thoroughly tamped. The face centering should be removed as early as possible and the concrete treated with a wire brush to the desired texture. If any blemishes occur they should be filled immediately after the concrete is brushed with the screenings from the dry concrete according to the gauge required.

Difficulty was experienced in arranging for the shutters to be struck at the right time for the brushing operation, but since this work was completed a liquid has been placed on the market which when painted on the centering retards the set of the cement coming in contact with it so that a much wider range of time is allowable, and the work of brushing is made easier, thereby facilitating more accurate results.

A great deal of work yet remains before this new method of finishing cast *in-situ* concrete will reach that stage of perfection attained by the older building materials, but the results have fully justified the labours expended on it. At a cost of considerably less than half that of Portland stone a result has been achieved that is fully worthy of the occasion.

There is no doubt that concrete faced by this method will last as long as ordinary Portland cement concrete. Quite pleasing results can be obtained by carefully grading the ordinary aggregates in the concrete without utilising a layer of special concrete. In such a case the cost is still further reduced. Special layer concretes are only necessary for buildings of considerable architectural importance, and ordinary concrete can be made to give an effect in every way suitable for industrial purposes. It is important to emphasise that the two layers of concrete remain such only during casting and that as soon as the temporary steel plate is removed they flow together and set as one mass without a mechanical joint.

The contractor was Mr. Albert Monk.

Early High-Strength Concrete.

MR. JOHN S. LAIN, of Toronto, writes:

"The writer was superintendent on a ten-story reinforced-concrete factory building, and, in the course of construction, it was found imperative to pour the boiler room walls in a hurry to prevent a 'cave-in' of the excavations, which were 20 ft. below grade. Had this happened, several houses would have gone too, and also endangered an adjacent factory.

"Forms for the walls were speedily erected in the usual manner, and the concreting commenced.

"First, a 1 : 2 mix of Portland cement and sand was poured 'soupy' all around the walls to a depth of about 3 ins. The real 1 : 2 : 4 mix was then poured in the following manner:

"The usual amount of mixing water was decreased until the resultant concrete was not a 'soft' mix nor yet a 'harsh' one, but a 'rolling concrete,' just workable, and of this water ½ gall. per bag of cement was replaced by ½ gall. of commercial calcium chloride ($CaCl_2$) solution made up in the proportion of one pail $CaCl_2$ to two pails of water. The mixing time was increased to 1½ minutes after all materials were in the drum.

"Sixty-five cubic yards were poured to complete the walls on a Saturday afternoon, and during the pour three test cylinders were taken. On the next day the top of the wall was flooded, and the forms thoroughly wetted. On Monday morning the forms were stripped, and a test cylinder broken at noon gave a compressive strength of 1,820 lbs. per sq. inch. The cylinder was less than 44 hours old.

"The excavations between the outside walls and bank were filled in during the afternoon, the walls taking all the stress. For three days the inside and top of the wall were thoroughly cured by sprinkling water over them. The average temperature during the week-end was 70 deg. F.

"The rules for early high-strength concrete are as follows:

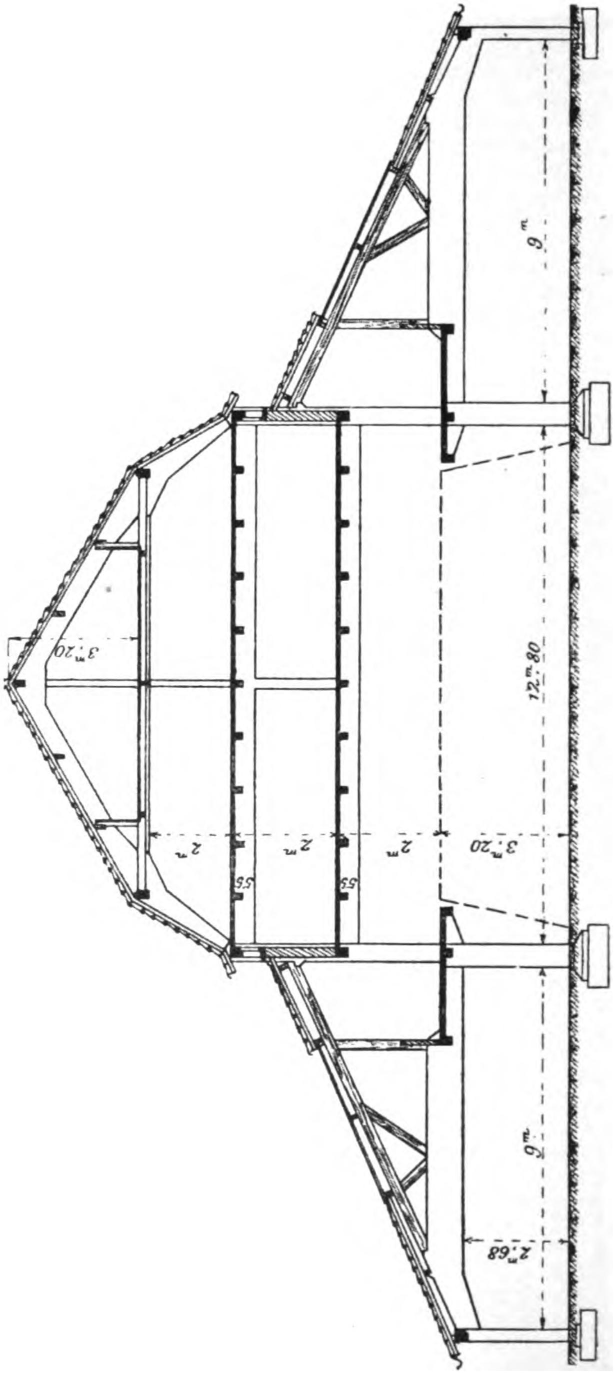
"(1) Decrease the usual amount of mixing-water generally used;

"(2) Hold half a gallon of calcium chloride solution, made in the proportion of 1 calcium to 2 of water;

"(3) Increase the mixing time as long as possible; the longer the better up to five minutes;

"(4) Place the concrete at 70 deg. F. and keep it so for two or three days; this can be done easily and cheaply in winter by pre-heating the aggregates, running a perforated steam pipe through the pile, heating the water to about 100 deg. F., and covering the work as soon as placed;

"(5) Keep the concrete moist; more good potential concrete is spoiled by lack of curing than any other single item."



Factory at Auneuil (Oise): Cross Section. (*See p.* 713.)

New Specification for Concrete in French Factory.

The construction of a new factory at Auneuil (Oise) is notable on account of the use of a new specification for the reinforced concrete. Experiments carried out during late years have shown that the specification of so many pounds weight of cement to a cubic yard of finished concrete and a predetermined volume ratio of sand to coarse aggregate are not alone a guarantee of the strength of the resulting concrete. For this reason the consulting engineer, M. G. Magnel, of Ghent, decided to impose a specification of a more modern nature on the contractors.

The building, of which we reproduce illustrations from "Le Gènie Civil," was designed to contain a furnace and three drying-floors. As it was essential that the ground floor should be free from obstructions, no intermediate columns were permitted. Neither was it possible to span the distance of 40 ft. by ordinary beams, so the three floors were suspended from the main roof frames, which were made suitably strong.

In plan the building measures about 312 ft. by 104 ft., and consists of a central portion supported by columns at 40-ft. centres and of two low wings each of 29 ft. span.

The main frames are hinged at their bases and have ties both at the second-floor level and half way between this floor and the roof. The frames are spaced about 11 ft. apart and connected by reinforced concrete purlins on which the rafters and tiled roof are supported. There is an expansion joint near the middle of the building. The live load on the floors is 125 lbs. per sq. ft.

The specification contains several notable clauses of which the following summary gives some indication.

(1) The allowable stress on the concrete in the columns shall not exceed 0·24 of the crushing strength of the concrete at seven days, on 8-in. cubes made on the job, nor in any case 720 lbs. per sq. in.

(2) For the slabs and frames these figures are to be replaced by 0·28 and 920 lbs. per sq. in. respectively.

(3) The contractor shall exercise his own choice of the fine and coarse aggregates and the relative proportions of these, the weight of cement per cubic yard of concrete, as well as the consistency of the mix. He shall, however, be limited by the following restrictions.

(*a*) The ratio between the weight of cement in kilos and the volume of water in litres shall not be less than 1·85;

(*b*) The ratio between the volume of fine aggregate (that is, the material smaller than $\frac{3}{16}$-in. ring) and that of the gravel or broken stone shall be between 0·5 and 1·0;

(*c*) The slump shall not exceed six inches;

(*d*) The crushing strength at seven days of 8-in. cubes cast in metal moulds on the job shall be not less than 3·5 times the figure taken by the contractor as the safe working stress.

(4) The cement used shall be rapid-hardening Portland cement.

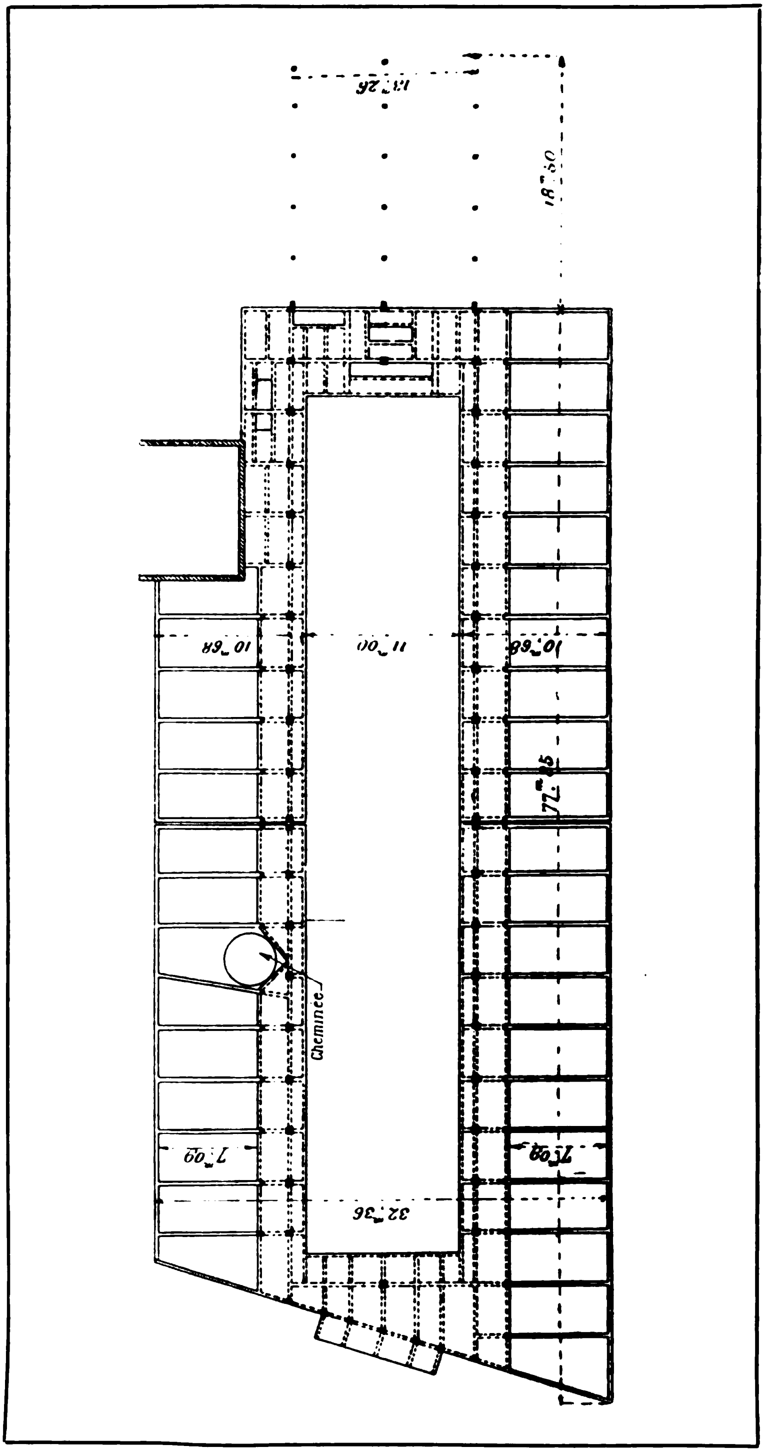
The specification is based on the fact that the strength of a concrete of a given age depends on the weight of cement used and on the quantity of mixing water per cubic yard. That is, of course, within reasonable limits. Following Bolomey's formula that $f_c = K\left(\frac{C}{E} - 0{\cdot}50\right)$ where C = wt. of cement in kg. and E = volume of water in litres, and taking $K = 200$ kg/cm^2 for French rapid-hardening Portland cements, we get (remembering that $C \div E$ shall be not less than 1·85)

$$f_c = 200\,(1{\cdot}85 - 0{\cdot}50) = 270 \text{ kg/cm}^2$$
$$= 3830 \text{ lbs./sq. in.}$$

As the law only purports to give f_c to within 10 per cent. we take 245 kg/cm^2.

Then $0{\cdot}28 \times 245 = 68$ kg/cm^2, which is about the maximum stress allowed.

M. Magnel foresees the time when the contractor will be penalised for any notable decrease in the strength of concrete below what is specified. On this particular job the concrete was of much higher strength than actually required. No doubt this was due to the contractor's want of knowledge of this method of designing concrete mixes and his desire to be on the safe side. Evidently he used a higher value of $C \div E$ than was necessary.—W. S. G.



Factory at Auneuil (Oise): General Arrangement. *(See p. 713.)*

Highway Bridge over the River Marne.

The reinforced concrete highway between Jaulgonne and Varenne over the river Marne, in the Department de l'Aisne, has a clear span of 246 ft. and consists of a three-hinged arch with suspended roadway.

The masonry abutments of the previous bridge have been preserved in their entirety and enlarged as necessary for compliance with the designs for the new bridge. The additions to the abutments were carried out in mass concrete faced with pre-cast concrete with joints similar to those in masonry work.

At each abutment there are two hinges, of the Mesnager type, for the articulation of the two arch ribs. The springings for the arches are in reinforced concrete and project as cantilevers from the inner face of the abutments. The articulations proper are formed by a series 110 bars of 30 mm. diameter arranged in pairs and crossing at the point of articulation, the ends of the bars being embedded for a length of 1·20 m. in the concrete of the arch ribs and the springings respectively. The hinge at the crown of each arch rib is formed by two steel castings providing a bearing for a steel roller of 14 cm. diameter (see *Fig.* 1).

The arch ribs are 60 cm. wide throughout their length by 1·70 m. deep at the springings, where they are connected by a beam, 2 m. in width by 1·62 m. in depth, strongly reinforced in the tension and compression areas. The ribs are pierced by openings, as shown by *Fig.* 1, with the objects of keeping down the dead weight and of avoiding the cost of unnecessary material. It will also be noticed that the depth of the ribs increases from the springings to a point midway between them and the crown, and then decreases towards the central hinge, 2·40 m. being the maximum depth of each rib.

Spaced 5·90 m. apart between their interior surfaces, the ribs are connected at intervals of 2·75 m. by transverse bracings. These members, 25 cm. by 80 cm. in cross section at the middle, are increased to 1·70 m. in depth at the ends to form rigid connections with the arch ribs. The vertical members for support of the roadway are also spaced 2·75 m. apart; their cross section is octagonal in shape, measuring 35 cm. by 50 cm. and their height varies according to the curve of the arch ribs. Each pair of verticals is connected by transverse girders, the ends of which are continued as cantilevers for

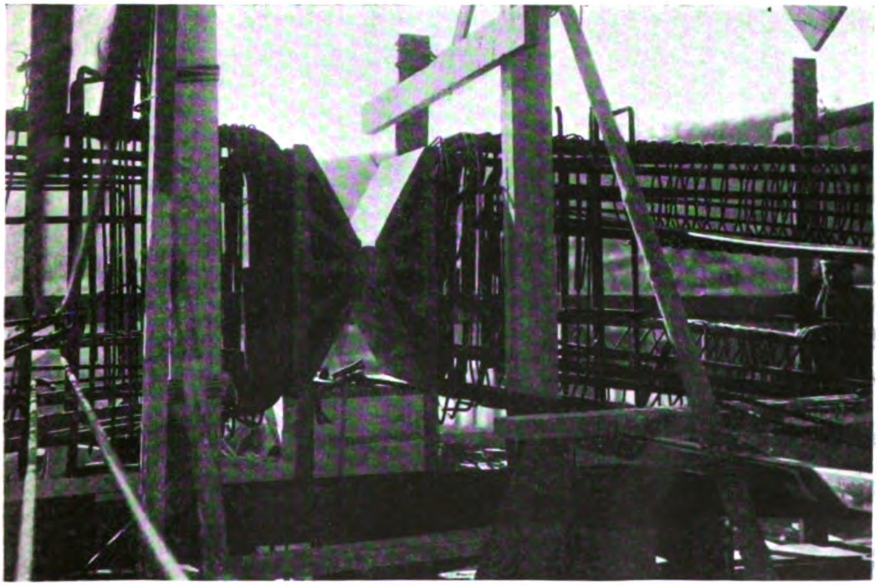


Fig. 1.—Steel Hinge at Crown of Arch Rib.

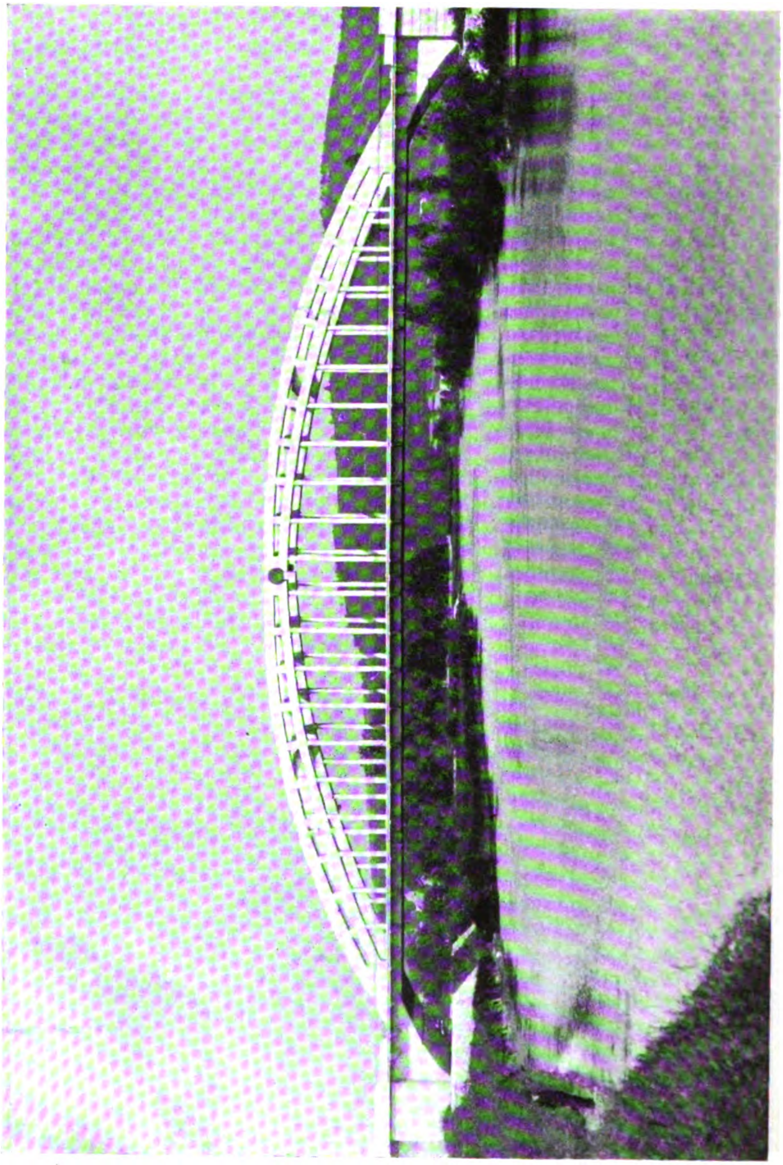


Fig. 2.—Highway Bridge over the River Marne.

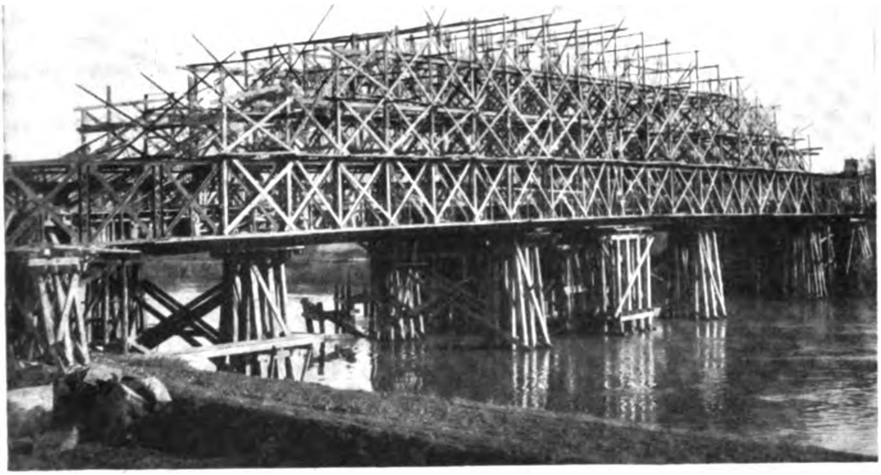


Fig. 3.—Formwork in Position.

support of the footpaths carried along each side of the bridge. The transverse girders measure 30 cm. wide by 80 cm. deep, and the cantilevers, which project 1·70 m. beyond the outer face of the vertical members, are 20 cm. wide, with a maximum depth of 95 cm.

The upper bracings, the transverse girders, and the vertical members constitute indeformable frames which are in themselves sufficient to assure the transverse rigidity of the construction. As an additional precaution, however, the arch ribs are further stiffened by horizontal wind bracings crossing diagonally from the corners of each panel formed by the upper bracing members, but at certain points where diagonal bracing is unsuitable inclined portals of arched form have been employed in their stead.

The decking of the bridge is formed by continuous slabs supported on and monolithic with three continuous longitudinal beams carried by the transverse girders. The slabs are 16 cm. thick, reinforced in both directions; the central longitudinal beam is 20 cm. wide by 40 cm. deep below the slab, and the two side beams are 20 cm. wide by 77 cm. deep. The roadway is paved with compressed asphalt and provided with steel plates at the points where expansion joints occur, one at each end and one at the centre. The footpaths, with a clear width of 1 m., are formed by a slab 6 cm. thick stiffened by a rib, 15 cm. by 17 cm. in cross section, along the outer edge and supported by the cantilevers previously mentioned. The surface of the paths consists of cement mortar 2 cm. in thickness. Each footpath is bordered by wrought-iron railings 90 cm. in height.

Fig. 3 shows the timbering employed in the construction of the bridge, which was built by La Société des Grands Travaux en Béton Armé, at a cost of 705,581 francs, including expenditure in connection with the temporary bridge which had been erected on the site.

On completion, the 3rd, 4th, and 5th spans of the footpaths from each end of the bridge were subjected to a distributed load of 115 lbs. per sq. ft., and the four central spans of the decking were subjected to a distributed load of 410 lbs. per sq. ft. The maximum deflections registered when the loading had been in place for 24 hours were:—On the axis of the upstream span, 36 mm., and on the axis of the downstream span, 33 mm. After removal of the superimposed loading, permanent deformations remained as follows:—13 mm. upstream span and 15 mm. downstream span.

The rolling loads for the next test consisted of five steam rollers, two of 18 tons, two of 12 tons, and one of 6 tons, a total of 66 metric tons. The rollers were employed in different formations—stationed at different points in single file, two abreast and in a group as closely together as possible. The maximum deflection recorded was 15 mm., and there was no permanent deflection after the passage of the rollers.

The works were carried out under the direction of M. J. Delforges, Ingénieur d'Arrondissement à Chateau-Thierry, with M. Noel as Ingénieur-en-chef.

Concrete Work at Ymuiden Lock.

At the entrance of the canal from Ymuiden to Amsterdam there is at present under construction a lock which will be the largest in the world. Up to the present time 84,000 cu. yards of concrete have been poured into this work through two "Insley" chuting plants.

According to Mr. B. Peiser, writing in "De Ingenieur," some trouble has been met with in pouring the concrete, and this is mainly due to the chutes overflowing. The causes of this have been :—

(*a*) unsuitable slope of the chute and the formation of dips in the line.

(*b*) variation in the mix resulting in wetter concrete overtaking a previous dry batch moving slowly, and flowing over the latter and over the edge of the chute as well.

(*c*) large stones preventing the discharge valve at the hopper-head from closing and at the same time allowing an excessive amount of concrete through to overflow from the already full chute.

(*d*) too small and shallow a form of chute.

The original and the altered chute, with raised edges, are shown in our illustrations. Considerable difficulty was found in altering the position of the end of the chute which was counterbalanced when empty. Finally the concrete was discharged into bins and delivered from these by wooden chutes. The chute of the spouting plant was only shifted every four hours.

The plant was designed to discharge 78 cu. yds. per hour; at first only one-third of this amount was placed, but later as much as 920 cu. yds. were poured in 10½ working hours.

Naturally the formwork for such rates of pouring had to be specially designed—in some cases the height poured was 12 ft. in five hours, and the concrete pressure increased very rapidly each hour. When using slag cement the forms had to be capable of resisting the full concrete pressure due to 12 ft. head, as the first concrete poured had not set when work was stopped at the end of the five-hour period.

With main side walls 70 ft. high it was obviously impossible to stay the forms from the outsides, so the contractor devised a

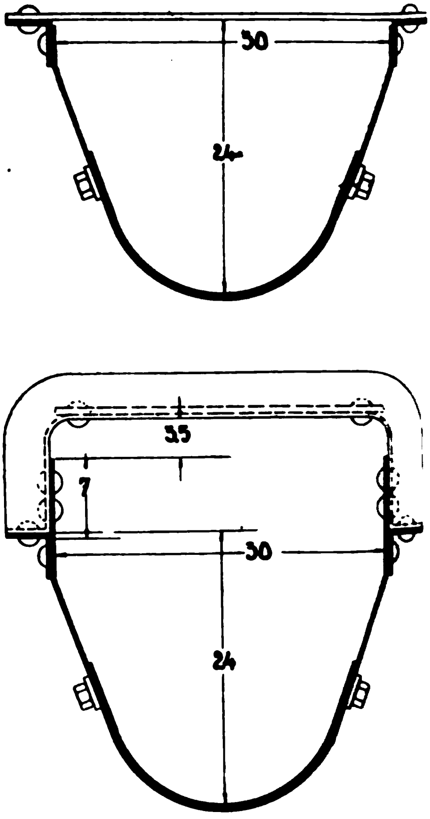


Fig. 1.—Forms of Chute.

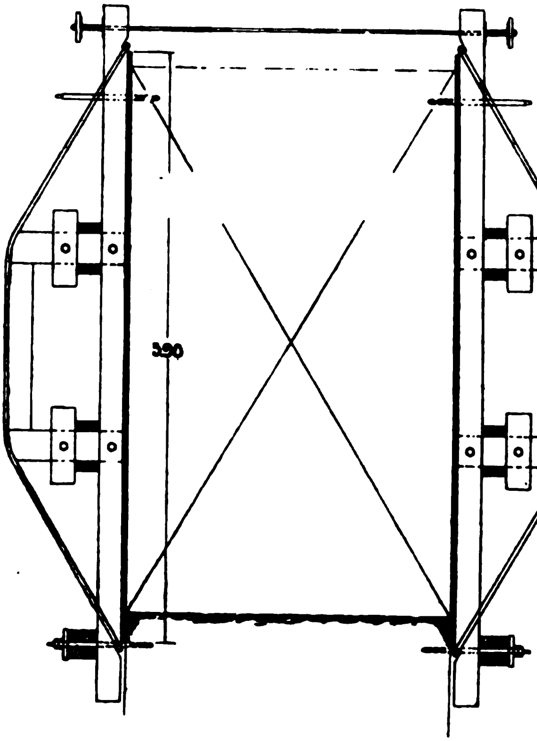


Fig. 2.—Formwork.

kind of trussed form (see *Figs*. 2 and 3). The bolts were 1¼-in. diameter and the length of thread 6 in. The thread was surrounded by a spiral of steel, ¼ in. in thickness, and concreted in. When the concrete had set the bolt was unscrewed leaving the steel spiral in the concrete, the holes being filled later.—W. S. G.

Questions and Answers.

Question.—Is the cost of a large building constructed of reinforced concrete more expensive than the same building in steel-framed construction? If so, what advantages, if any, has reinforced concrete to offer over steel encased in fireproofing?

"Regular Reader."

Answer.—The cost of the frame of a reinforced concrete frame building generally works out at about 25 per cent. less than that of a steel-frame building if the cost of fire-proofing the latter is taken into account so as to make it comply with the L.C.C. 1909 General Powers Act or similar Acts or Regulations in force in various parts of the country.

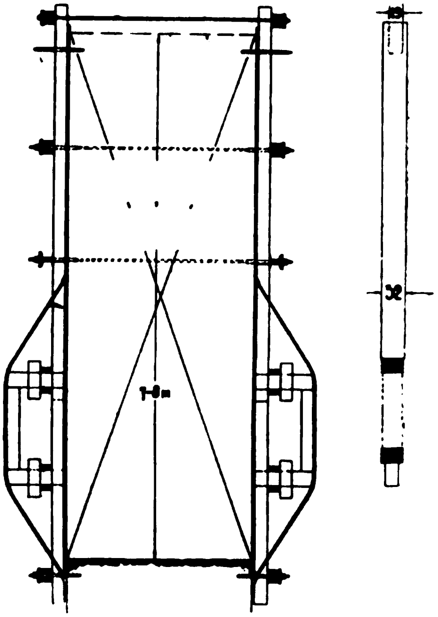


Fig. 3.

Economical Dimensions for Tanks and Reservoirs.

In designing tanks the engineer is often given a capacity to work to without any restrictions on the linear dimensions. For such cases Dr. E. Kuester has recently published in "Beton u. Eisen" an article showing how to choose the most economical dimensions.

For circular tanks $V = \frac{\pi D^2}{4} \times H$ or

$H = \frac{4V}{\pi D^2}$ where H and D are expressed in feet, and the following extra symbols are used:

C_F = cost per sq. ft. of the floor including any mass concrete, waterproofing, rendering, etc.
C_R = cost per sq. ft. of the roof including waterproofing, etc.
C_W = cost per sq. ft. of walls complete.

It is assumed that there is one column, h feet long to each n sq. ft. of floor area, and that C_C = cost of column per ft. length. The costs of column capitals and footings are to be included in the costs of roof and floor respectively.

If these units prices do not vary much for small alterations in the values of D and H, the total cost

$$K = \frac{\pi D^2}{4}(C_F + C_R) + \pi D H C_W + \frac{\pi D^2}{4n} H C_C.$$

But $H = \frac{4V}{\pi D^2}$.

Therefore $K = \frac{\pi D^2}{4}(C_R + C_F) + \frac{4VC_W}{D} + \frac{VC}{n}$, hence the cost of the columns is independent of D and is a constant proportion of the total cost K. Omitting the cost of the columns, we obtain

$$K = \frac{\pi D^2}{4}(C_R + C_F) + \frac{4VC_W}{D}$$

$$\therefore \frac{dK}{dD} = \frac{\pi D}{2}(C_R + C_F) - \frac{4VC_W}{D^2} = 0.$$

$\therefore D = 2\sqrt[3]{\frac{VC_W}{\pi(C_F + C_R)}}$ is the value of the diameter which makes the total cost a minimum.

The minimum cost is,

$$K = \sqrt[3]{\pi(C_F + C_R)V^2C_W^2} + 2\sqrt[3]{\pi(C_R + C_F)V^2C_W^2}$$
$$= 3\sqrt[3]{\pi(C_R + C_F)V^2C_W^2}$$

or, "In the most economical circular tank the walls cost twice as much as the roof and floor taken together."

Economy of Rapid-Hardening Cement in Design.

By T. O'BRIEN.

[While the following notes are of interest as showing the possibilities of rapid-hardening Portland cement, we would point out that we do not agree with all the statements made. We would particularly warn builders of the danger of using the smaller sections mentioned without the advice of a competent engineer.]

MANY methods have been adopted since the advent of aluminous and rapid-hardening Portland cements to take advantage of the greater strength of these materials. Contractors realised at once that quick-hardening properties would considerably reduce their shuttering costs. More recently experiments have been made, and jobs actually constructed, with mixtures that were at one time thought of only in terms of mass concrete.

If, instead of revising the proportions of the mixture in order to use less cement, the greater strength, both initially and finally, were taken into consideration in the calculation of reinforced concrete members, a large saving would result in the total cost to the clients as follows:—

(1) The thickness of slabs and sections of beams and columns would be considerably reduced.

(2) The net area of steel would be increased, but not sufficient to counterbalance the large saving in item (1).

(3) The increase in steel in item (2) would give a fillip to the reinforcing bar trade, which would encourage the present programme of the British steel manufacturers and rolling mills throughout the country.

As is now universally accepted, a 4 : 2 : 1 mix of concrete in which rapid-hardening cement has been used, attains a strength of more than 5,000 lbs. per square inch in 28 days, and nearly 7,000 lbs. per square inch in 3 months. These figures compared with the minimum strengths in Regulation 159, Section 23, of the L.C.C. (General Powers) Act, 1909, for reinforced concrete, are more than three times the necessary value in the first case and 2½ times that required for four months in the latter.

From these results it follows that with the usual factor of safety of four and a 4 : 2 : 1 mixture of concrete we can design for a safe compressive stress of 1,200 lbs. per square inch one month after mixing. This factor increases to five at the end of a 3-months' period, but the fact that the structure can be in daily use by this time and carrying the full loads for which it has been designed implies that the lower figure should be worked to.

Again, in tension with a 3 : 1 cement mortar the higher early-strength cement has an ultimate strength at 24 hours equal to that of ordinary Portland cement in 7 days. The increased figure for seven days is 1¼ times that for Portland cement at 28 days, and its own 28-day figure is a little more than this.

The present minimum L.C.C. figures for shear in concrete are very low for even ordinary Portland cements, as is shown by the makers' specifications and field tests made by contractors all over the country. With a factor of safety of four using rapid-hardening Portland cement a safe shear stress of 120 lbs. per square inch can easily be obtained within a week of mixing and a proportionate increase in grip stress or adhesion between concrete and steel naturally follows at 200 lbs. per square inch.

With the above stresses, and taking 16,000 lbs. per square inch for mild steel bars, the formulæ for beams and slabs using the following notation develops as under :—

$A = \dfrac{Rc}{t \times a}$ = area of tensile reinforcement in inches.

$a = d - \dfrac{n}{3}$ = lever arm of resistance moment.

$\dfrac{A}{d}$ = ratio of lever arm to effective depth of slab or beam.

B = bending moment of external loads and forces.

b = breadth of slab in inches, or breadth of rectangular beam in inches.

c = permissible compressive working stress at extreme fibre of concrete in compression in pounds per square inch.

d = effective depth of beam or slab in inches, i.e. the distance from the top of the slab in compression to the centre of the tensile reinforcement.

Ec = elastic modulus of concrete in compression.

Es = elastic modulus of steel in tension or compression.

$m = \dfrac{Es}{Ec}$ = modular ratio.

n = distance of the neutral axis from the extreme fibre of the concrete in compression of the slab or beam in inches.

$n_1 = \dfrac{n}{d} = \dfrac{mc}{t + mc}$ = neutral axis ratio.

$p = \dfrac{nc}{2\,td}$ = percentage of tensile reinforcement.

$Rc = \dfrac{cbn}{2}\left(d - \dfrac{n}{3}\right)$ = resistance moment of the internal stresses in the slab or beam in terms of the permissible compressive working stresses.

t = permissible tensile working stress in tensile reinforcement in pounds per square inch.

Modulus of elasticity $\dfrac{Es}{Ec} = 10$ (for ratio of steel to 5,000 lbs. concrete).

$$\frac{n}{d} = \frac{10 \times 1{,}200}{16{,}000 + 10 \times 1{,}200} = \frac{12{,}000}{28{,}000} = 0{\cdot}429d.$$

$$\frac{a}{d} = d - \frac{0{\cdot}429}{3} = 0{\cdot}857d.$$

$$p = \frac{0{\cdot}429 \times 1{,}200}{2 \times 16{,}000} = 0{\cdot}0161\ bd.$$

$$Rc = B = \frac{1{,}200 \times b \times {\cdot}429d}{2}\,(0{\cdot}857d) = 221\ bd^2.$$

Taking a case of a 7-in. floor slab with "economic" reinforcement, and using present stresses of 600 lbs. per square inch on concrete and 16,000 lbs. per square inch on mild steel bars having ½-in. cover of concrete:—

$$Rc = 95bd^2 = 95 \times 12 \times 6{\cdot}25^2 = 44{,}530 \text{ inch lbs.}$$

$$At = \frac{44{,}530}{16{,}000 \times 0{\cdot}88 \times 6{\cdot}25} = 0{\cdot}506 \text{ square inches.}$$

This is equivalent to ½-in. diameter bars at 4½-in. centres. A usual distribution steel for this would be ⅜-in. diameter bars at 15-in. centres.

The average cost per square yard of this floor without shuttering at the present day on a basis of 54*s.* 0*d.* per cubic yard for 4 : 2 : 1 ordinary Portland cement concrete, and 18*s.* 6*d.* per cwt. for mild steel bars (fixed), is:—

		s.	*d.*
0·195 cubic yard concrete at 54*s.* 0*d.*	=	10	6
23 lbs. mild steel bars at 18*s.* 6*d.* cwt.	=	3	9½
		14	3½

Using rapid-hardening Portland cement and utilising the above-mentioned stresses a 5-in. floor will give a much great moment of resistance as follows:—

$$Rc = 221bd^2 = 221 \times 12 \times 4{\cdot}1875^2 = 46{,}500 \text{ inch lbs.}$$

$$At = \frac{46{,}500}{16{,}000 \times 0{\cdot}857 \times 4{\cdot}1875} = 0{\cdot}81 \text{ square inches.}$$

This is equivalent to ⅝-in. diameter bars at 4½-in. centres. Using the same distribution steel as before the comparative cost per square yard is:—

		s.	*d.*
0·139 cubic yard concrete at 56*s.* 6*d.*	=	7	10
35 lbs. mild steel bars at 18*s.* 6*d.* cwt.	=	5	9½
		13	7½

A saving of 8*d.* per square yard is thereby shown and this figure allows for the extra cost per ton of rapid-hardening Portland cement over ordinary Portland cement. The result is a 4½ per cent. reduction.

If we complete the price per square yard for each case by adding the shuttering costs the argument for the above analysis is still more favourable, as follows:

4 : 2 : 1 mix ordinary Portland cement—

		s.	*d.*
Concrete and steel	=	14	3½
Shuttering at 4*s.* 6*d.* sq. yd.	=	4	6
		18	9½

4 : 2 : 1 mix rapid-hardening Portland cement—

		s.	*d.*
Concrete and steel	=	13	7½
Shuttering at 1*s.* 6*d.* sq. yd.	=	1	6
		15	1½

This is a direct saving of 3*s*. 8*d*. on the total cost per square yard, or 19½ per cent. The figure of 1*s*. 6*d*. allowed in the latter case is based on the fact that with the quick hardening of the material mentioned, boarding may be removed from the floor in a quarter of the period usually allowed for ordinary concrete. Only one-third of the normal cost has been quoted, to allow for extra labour entailed in taking down and erecting many more times than would be done in the ordinary way in the same period of time.

If the weights of steel are compared it will be found that 50 per cent. more steel is used. The volume of cement used per square yard is, however, reduced, although the smaller quantity sells at a higher figure and consequently approximates to the same cost.

The large reduction in weight (in the case mentioned it is nearly 30 per cent.) will be appreciated by architects both as regards the sections of supporting reinforced concrete members and steel-frame buildings with concrete floors. Also, the sizes of foundations may be considerably reduced with a consequent reduction of loads on the ground.

From the foregoing there is every reason why advantage should be taken of the high values obtained with rapid-hardening Portland cements instead of the *laisser faire* attitude adopted by public bodies in this respect at the present time.

Book Reviews.

"Problems in Structural Design." By C. T. Bishop. 60 pp. Illustrated with line drawings and diagrams.

London: Chapman & Hall, Ltd. Price 10s. net.

THE author's "Structural Drafting," although based on American practice, has been well known in this country for many years as one of the best and most complete guides for steel structural designers and detailers.

The present volume consists of a collection of over 700 problems in steelwork design or detailing. They are really problems, because with very few exceptions the answers are not supplied. The book has been developed from problems used for many years, in mimeograph form, in the author's classes, it being his conviction as an instructor that students should be presented with a permanent record of the exercises performed by them in the course of their training in preference to the fleeting mediums of the blackboard or dictation.

The problems are classified in groups which correspond closely to the subject matter of Chapters XXX to XLIV forming Part III of "Structural Drafting," with four additional groups relating to such complete structures as tanks, bridges and buildings. Each group contains a number of problems of similar type (for example, there are 70 simple bending moment problems), it being the author's opinion that "by solving similar problems of a given type but with different dimensions, loads or specifications before proceeding to the next type, the student is able to get a better grasp of the fundamentals than when he designs only a single stringer and floor beam before taking up the trusses and the connections." The questions range from such an elementary one as "Find the maximum bending moment for a 15 ft. simple beam under a live load of 80 pounds per foot," to the complex "Design the steel skeleton frame of an office building" from the data supplied.

The book is suitable for instructors desirous of making or extending lists of problems on similar lines or for students' practice. Many of the problems are applicable to British practice without any alteration, but the great majority of them would require some adaptation of the American sections and units.—W. B. S.

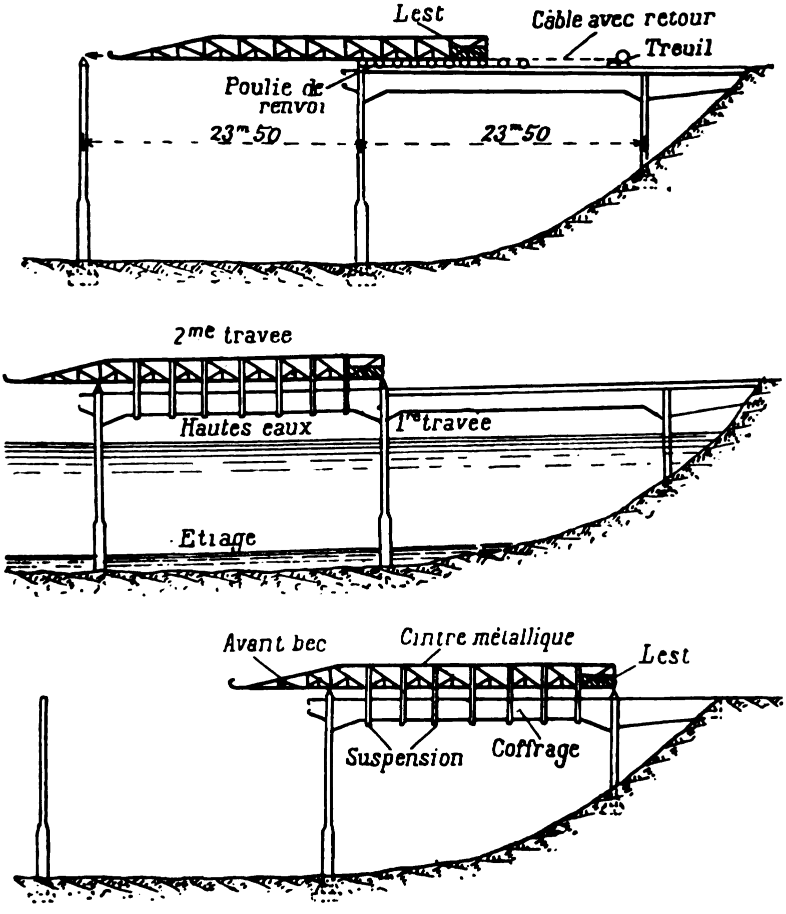
Books on Civil Engineering.

The McGraw-Hill Publishing Co., Ltd. of 6 Bouverie Street, London, E.C.4 have issued a new edition of their list of books on civil engineering subjects, covering bridges, buildings, cement, concrete constructions, contracts, drainage, highways, hydraulic, hydro-electric, irrigation, law, sanitary, shaft sinking, specifications, statics, structural, surveying, tunnelling and waterworks, etc.

Travelling Falsework for Reinforced Concrete Bridges.

QUICKLY-rising floods in rivers which bring down floating débris frequently cause damage to any form of scaffolding which has its support on the river-bed. To prevent such accidents M. Henry Lossier, the well-known French engineer, has devised a useful travelling scaffold for bridges of several spans. The method has been used during the construction of three bridges in North Africa. One of these comprised six spans of about 75 ft. on piers of about 40 ft. in height. The method of construction is clearly shown in our illustrations; for these and the description we are indebted to *Le Génie Civil,* which recently published an article on the subject by F. Willm.

The travelling centre consists of two steel girders, strongly braced together, from which the ordinary framework is suspended. The rear end is counterbalanced. As soon as the abutment and first pier have been constructed the travelling stage is moved forward as in steel-bridge work. The suspension rods are then fixed in position, and then the ordinary formwork for the girders and slabs. Rapid-hardening Portland cement



Three Stages in the use of Travelling Formwork for Bridges.

is used in order to release the forms as soon as possible. When the forms and suspension members have been removed the stage is moved on to the next span.

The travelling stage can be dismantled and removed in small parts when the job is completed. The advantages claimed for this method are (*a*) less timber to be transported to the site, (*b*) no piles needed in the river bed, (*c*) no obstruction to navigation, and (*d*) no danger to the workmen who use the stage as a footpath. —W. S. G.

Cement Injection at St. Paul's Cathedral.

The fifth report on the preservation work at St. Paul's Cathedral states that the work of preservation has continued to proceed satisfactorily during the period that has elapsed since the last report, dated January 10, 1927. The consolidation with cement and the reinforcement with rustless steel rods of all the eight main piers in the crypt have been completed. The timber strutting has been cleared away, the memorials and tablets have been replaced, and considerable progress has been made in the elimination of all evidence of the work carried out and in the restoration of the face of the masonry to its original appearance. It is now practically impossible to discern where the holes have been drilled. The crypt has been fully open to the public again for several months past.

The drilling, cementation and reinforcement of all the eight main piers from the level of the church floor upwards has made steady progress, and, on the average, has reached half-way up to the main cornice. The replacement of the iron ties, mostly fractured, inserted between the piers and bastions at the gallery level during the original construction, by a much stronger system of rustless steel ties is nearing completion, two of the four groups being finished, the third nearly so, and the fourth started.

In drilling the holes for the new ties, valuable information has been obtained as to the state of the interior of the piers both before and after the cement injections. Cores have been recovered from the holes drilled after injection and the injected cement is found to be filling all cavities in the core and to be adhering closely to the stone and mortar. It has occasionally been possible to obtain specimens of injected cement from these cores large enough for testing, and they have shown a resistance to crushing greater than that of Portland stone. A scheme of bracing between the drums from the level of the Whispering Gallery upwards has been approved in principle ; detailed designs are now being prepared for final consideration.

In carrying out the work it has not been found necessary to make any material deviation from the recommendations contained in the report of the Commission of Architects and Engineers, dated February 14, 1925. The series of levelling, plumbing and theodolite observations and of linear measurements have been continued at regular intervals and also the readings of the crack measurement plugs, with the result that no evidence of settlement in the foundations nor of injurious movement in other portions of the dome structure is to be detected. The observation and plotting of the theodolite survey of the dome area, including the piers, bastions and arches, have been completed, and it is proposed to extend this survey to other portions of the structure, and to complete the architectural survey.

Pont de la Tournelle, Paris.

In our last number we described the new Pont de la Tournelle, Paris. We regret we did not state that the consulting engineers who prepared all the calculations, together with the arrangement for opening the bridge at the crown by hydraulic jacks, were Messrs. Pelnard-Considère et Caquot. The method adopted for filling in with mortar between the jacks in such a manner that the pressure could be immediately sustained, was also devised by the same firm.

Estimation of the Proportions for Concrete.

Strength—Mean Slump Straight-Line Equation
and
The Mean Slump—Water Cement (volume) Ratio Equation.

By H. W. COULTAS, M.Sc. (Birmingham); B.Sc. (Leeds).
(Lecturer Dept. of Civil Engineering, University of Birmingham.)

THE purpose of this paper is to show how various factors in connection with the water-cement ratio theory of specifying the quantities of concrete can be put to practical use; to endeavour to express mathematically the relations between the various factors; and, finally, to show how to specify the use of this theory in practice.

The following is a summary of the results obtained :—

A_f = sum of the volumes of the aggregates in a Field Mix to unit volume of cement.

A_n = sum of the volumes of the aggregates in a Nominal Mix to unit volume of cement.

A_r or a_r = volumes of the mixed aggregates in a Real Mix to unit volume of cement.

Then

$$A_n = C_f A_f \qquad (1)$$

$$\text{and } A_r = C_n A_r \qquad (2)$$

$$\text{or } A_r = C_f C_n A_f \qquad (3)$$

Values of C_f and C_n, which are shrinkage factors, have been ascertained and are given in the paper.

Let f = strength of concrete at 28 days in lbs. per sq. in.
S_m = mean slump in inches.
C = factor dependent on the cement.
W = factor dependent on the mixing and rigidity of control.
m_r = Fineness modulus of the real mix.
b = factor dependent on W. and C.
x = water-cement ratio by volume.

Then for Portland and aluminous cement concretes,

$$f = \frac{C}{W^x} \qquad (4)$$

For P.C. concrete,

$$f = \left(\frac{C}{W^{x_0}} + 500m_r - 1000A_r + 50A_r^2\right)\{(1 + b) - bS_m\} \qquad (5)$$

For aluminous cement concrete replace S_m by $S_m + 1$

The mean equation is

$$S_m = N - \frac{13{\cdot}05}{x - 0{\cdot}09\left(\frac{5{\cdot}4A_r}{m_r} - 3\right)} \qquad (6)$$

where N = 22·55 for Portland cement concrete and 21·55 for aluminous cement concrete.

To find x_0 in equation (5) use equation:

$$\frac{C}{9^{x_0}} - \frac{C}{9^{0\cdot7}} = 500 \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Values of C, x_0, W, and b are given in the text.

Estimating the Quantity of Cement per Cubic Yard of Finished Concrete.

Barrels of cement per cubic yard of concrete (1 Barrel = 376 lbs.)

$$= \frac{6\cdot75}{0\cdot5 + x + \dfrac{W_f + W_c}{166\cdot6.}} \quad . \quad (8)$$

Stanton Walker equation where W_f and W_c are the weights of the fine and coarse aggregates.

Converting this for use in British practice.

Bags of cement (of approximately 2½ cubic feet) per cub. yd.

$$= \frac{10\cdot8}{0\cdot5 + x + (0\cdot67 + 0\cdot018m_r)A_r} \quad . \quad . \quad . \quad (9)$$

Shrinkage Factors for Fine and Coarse Aggregate.

The work in this paper is based on the equations and curves given by Professor Duff Abrams in his various bulletins and summarised by Mr. A. E. Wynn, B.Sc., in his paper, "Controlling the Manufacture of Concrete to obtain Uniformity of Strength." * Certain data obtained by Messrs. W. A. Slater and Stanton Walker from field tests at Newark Bay and Camden, U.S.A., and given in their paper "Report of Field Tests of Concrete used in Construction Work," † have been used for analysis. In a section dealing with the estimation of the quantity of cement per cubic yard of concrete, the equation of Mr. Stanton Walker ‡ has been amended to meet the requirements of British practice.

In the equations which follow the values of the fineness modulus of various aggregates are those given by Professor Abrams on the strength, aggregate and slump curves given in Mr. Wynn's paper (see *Figs.* 1 and 2).

The equations given are a fair measure of the strength of concrete provided that at least one-third of the aggregate is sand or fine aggregate (i.e. material smaller than that which will pass through a No. 4 sieve) and that the quantity of coarse aggregate of any one size is not less than one-third as great as that of the next larger size. The aggregate therefore must be more or less uniformly graded. It is also indicated that the sand should not be more than two-thirds of the total aggregate to meet this criterion.

The proportions of the concrete may be given in three ways, viz. The Real Mix, the Nominal Mix, and the Field Mix.

The Real Mix: Expressed as unit volume of the cement to A_r volumes of the *mixed* aggregates measured dry and compacted in a standard manner.

The Nominal Mix: Proportions such as 1 : 2 : 4 expressed in terms of the volumes of the dry and rodded materials. The sum of the volumes of the dry and rodded fine and coarse aggregates to one volume of the cement will be expressed as A_n volumes.

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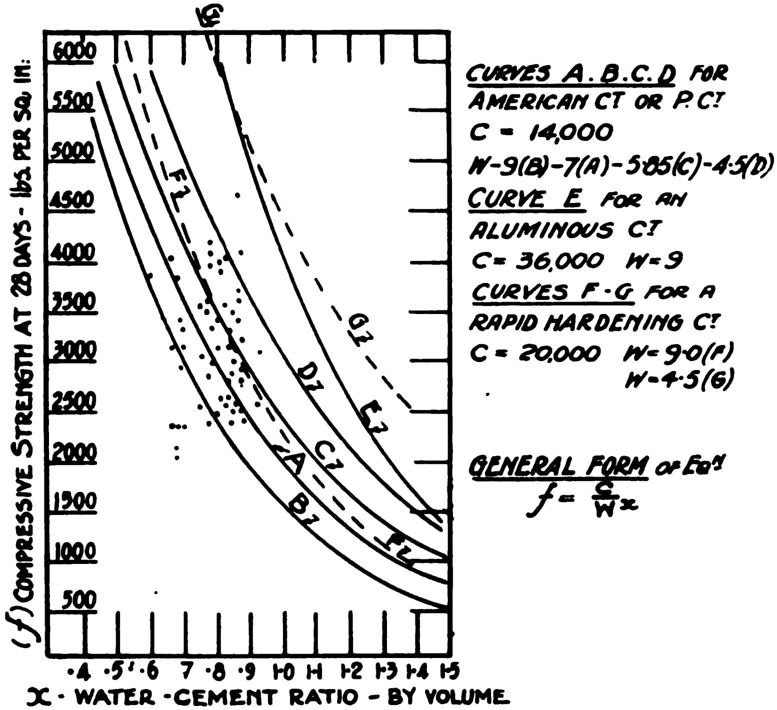
* "Concrete and Constructional Engineering," June, July, August, 1926.

† "Proceedings of the American Society of Civil Engineers," January, 1925.

‡ "Concrete and Constructional Engineering," February, 1927.

The Field Mix: In the field, the material in the bin or stock pile contains more or less moisture and is measured in a loose condition. Proportions stated in terms of the aggregate in the condition found on the job and measured loose are called the Field Mix. The sum of the volumes of the wet and loose fine and coarse aggregates to one volume of the cement will be expressed as A_f volumes.

The Fineness modulus of a mixture is the weighted mean of the moduli of the separate aggregates (when dry)—it will be denoted by m_r; m will represent the fineness modulus of a sand or coarse aggregate separately.*



RELATION BETWEEN WATER-CEMENT RATIO AND STRENGTH

MINIMUM WATER RATIOS – ·4(P.CT) ·7(AL.CT) ·4(R.H.CT)
PLOTTED POINTS – TEST DATA 1-2·4-3·6
(C = 14,000) FIELD MIX – NEWARK BAY

Fig. 1.

(Approximate) Relations between the Field, Nominal, and Real Mixes to be used in the estimation of the proportions and quantities for concrete and in the strength—mean slump straight line equation for concrete.

Dry sand when mixed with water increases in bulk to a maximum when the water by weight is about 5 per cent. of the weight of the dry rodded loose sand. It then decreases in bulk until when the percentage weight of water is

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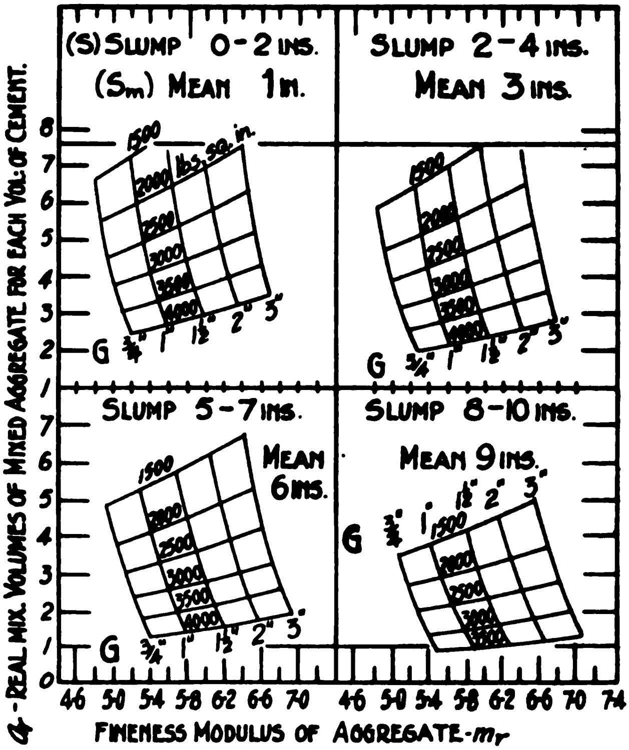
* See Mr. Wynn's paper.



RELATION BETWEEN VARIOUS FACTORS AND STRENGTH (f) FOR C = 14000, W = 9

GEN'L FORM (f)-(Sm) EQN: $f = \left(\frac{C}{W}x_o + 500m_r - 1000a_r + 50a_r^2\right)\{(1+b) - bS_m\}$

$C = 14000,\ W = 9,\ x_o = \cdot 63,\ b = \cdot 066$ – AMERICAN CT

Fig. 2.

about 17½ per cent. in the case of coarse sands to about 25 per cent. for fine sands the percentage bulking is nil. The data given in the following table is taken from the paper in "Concrete," January, 1925, by R. R. Litehiser, entitled "The Effect of Moisture in Sands in Proportioning Concrete Mixtures."

Fineness Modulus of the Sand.	Weight of Dry Loose Sand per cu. ft.		Percentage Bulking.									
		Per cent. Water by Weight.	0 Dry Loose.	1	2½	5	7½	10	15	17½	20	25
2·65	115 lbs.		8·5	18·2	30·3	41·8	35·2	33·9	15·6	0		
2·30	108 ,,		5·82	15·2	34·5	43·2	41·0	38·6	24·6		2·3	
1·20	102 ,,		5·35	41·8	50·4	52·5	47·1	43·1	27·8			1·0

Referring now to the tests of Mr. Stanton Walker ("Proc. Amer. Soc. Civ. Engs.," Jan. 1925), the respective fineness moduli of the sand and gravel used were 2·77 and 6·84 (Camden Tests). The sand contained 5 per cent. of water by weight and the gravel 2½ per cent. Tests of field mixes gave results as follows:—

Volume, damp and loose	1–3·5–5·9	1–2·8–4·7	1–2·3–3·9	1–1·7–2·9	1–1·4–2·3	1–1·3–2·1
Volume, dry and puddled . . .	1–2·7–5·3	1–2·2–4·2	1–1·8–3·5	1–1·4–2·6	1–1·1–2·1	1–1·0–1·9
A_f volumes . . .	9·4	7·5	5·2	4·6	3·7	3·4
A_n "	8·0	6·4	4·3	4·0	3·2	2·9
Ratio $\frac{A_n}{A_f}$	·85	·855	·83	·865	·865	·85

Plotting A_n against A_f a good straight line resulted whose slope was 0·85.

A_n volumes in this case = 0·85A_f volumes.

NOTE.—The slump figure is that obtained by slumping the mix immediately after it has been tamped into its mould: not after waiting for 3 minutes.

Consider the sand volumes from the table of field tests.

$$\text{Ratios}\left\{\frac{\text{Sand, dry and puddled}}{\text{Sand, damp and loose}}\right. : \frac{2{\cdot}7}{3{\cdot}5} : \frac{2{\cdot}2}{2{\cdot}8} : \frac{1{\cdot}8}{2{\cdot}3} : \frac{1{\cdot}4}{1{\cdot}7} : \frac{1{\cdot}1}{1{\cdot}4} : \frac{1{\cdot}0}{1{\cdot}3}$$

$$= 0{\cdot}77 \quad 0{\cdot}785 \quad 0{\cdot}782 \quad 0{\cdot}82 \quad 0{\cdot}785 \quad 0{\cdot}77.$$

The average value is 0·786.

Similarly considering the gravel aggregates.

$$\text{Ratios}\left\{\frac{\text{Gravel, dry and puddled}}{\text{Gravel, damp and loose}}\right. : \frac{5{\cdot}3}{5{\cdot}9} : \frac{4{\cdot}2}{4{\cdot}7} : \frac{3{\cdot}5}{3{\cdot}9} : \frac{2{\cdot}6}{2{\cdot}9} : \frac{2{\cdot}1}{2{\cdot}3} : \frac{1{\cdot}9}{2{\cdot}1}$$

$$= 0{\cdot}900 \quad 0{\cdot}895 \quad 0{\cdot}895 \quad 0{\cdot}900 \quad 0{\cdot}912 \quad 0{\cdot}906$$

The average value is 0·900 (*very nearly*).

The change in volume of the gravel is due to the rodding in a standard manner, not to the water content.

Assuming Field Mixes of
Cement Sand Gravel
of the kinds used in the tests.

Cement	Sand	Gravel
1	1	2
1	2	4
1	1½	3
1	2	3

Using the Shrinkage Factors obtained for sand, ·786, and gravel, 0·9, the Shrinkage Factor Field to Nominal Mix will be

$$\left\{\frac{1 \times {\cdot}786 + 2 \times {\cdot}9}{3}\right. = \begin{matrix}\left.\begin{matrix}0{\cdot}862\\0{\cdot}862\\0{\cdot}862\end{matrix}\right\}\\0{\cdot}855\end{matrix}$$

Therefore when the loose sand is one-half in volume of the gravel the shrinkage factor is 0·862, and the water content of the sand ($m = 2{\cdot}77$) is 5 per cent. When the sand ratio increases there is a slight drop in the shrinkage factor from 0·862 to 0·855. For the proportions generally taken in practice for the given conditions a shrinkage factor of 0·86 appears to be a good and approximate mean.

Working on the preceding lines a table has been drawn up for sands of varying fineness and in all cases allowing a shrinkage factor for the coarse aggregate of 0·9, irrespective of the water content.

[TABLE OF SHRINKAGE FACTORS C_F.]

Where $A_n = C_f A_f$.

These results were obtained by using the bulking percentages given by Mr. Litehiser in his paper.

Sand. m.		Grading of the Sand.	Dry Loose	Percentage Moisture Content of the Sand.					
				1	4	5	10	15	20
	2·65	0–4	·90	·885		·838	·84	·86	1
	2·62*				·856				
	2·45*				·856				
	2·3	0–8	·91	·885		·825	·83	·86	1
	1·2	0–50	·91	·83		·81	·82	·85	·9
	2·77	0–4				·86			
From Field Tests	3·21*	0–4				·87			

It is recommended that a very fine sand be not used for the making of good concrete, i.e. sand having an m of less than 1·5 not to be used. For sands having values of m ranging from 2·0 to 3·0, the shrinkage factor C_f works out to be, for the conditions stated,

Sand and Gravel.	Percentage Moisture Content of the Sand.					
Dry and loose.	1·0	4†	5·0	10·0	15·0	20·0
0.9 to 0.91	0·885	0·856 to 0·86	0·825 to 0·86	0·830 to 0·87	0·86	1·0

Regarding the 5·0 per cent. water content, Cf appears to have an average value of 0·84 and the 10 per cent. — 0·85

For a coarse sand use the higher value and a fine sand the lower one.

The Relation between A_n and A_r.

In the paper given by Messrs. Stanton Walker and Slater the following figures are given :—

a_n . . .	5·2	4·2	6·6	5·3	4·5	7·3	6·0	5·1	4·3	5·1	5·5	5·4	5·2
a_r . . .	4·8	3·8	5·8	4·6	3·9	6·7	5·4	4·5	3·8	4·5	4·8	4·8	4·8

the sand percentage ranging from 50 to 25 and the fineness modulus of the mixed aggregates from 4·8 to 5·9. The aggregate was graded 0–$\frac{3}{4}$″.

Plotting A_r against A_n a straight line is obtained passing through the origin and the slope of which is 0·9; let C_n represent this slope,

then $$A_r = C_n A_n = 0{\cdot}9\ A_n.$$

Sutherland and Clifford for an aggregate (0–1$\frac{1}{2}$″) give $C_n = 0{\cdot}86$ and in another case, 0·88. Wynn states that for most general cases it is, 0·875.

A general value of C_N can then be taken as 0·875.

The Relation between A_r and A_f.

$$A_r = C_n C_f (A_f).$$

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* Calculated from data given for the aggregates used in the Newark Bay tests of Messrs. Stanton Walker and Slater.

† Newark Bay Tests.

Estimating Quantities for Concrete.

The equation developed in this section is based on the formula given by Mr. Stanton Walker in his paper in *Concrete*, February, 1927.

This equation is

$$\text{Barrels (American) of cement per cubic yard of concrete} = \frac{6{\cdot}75}{0{\cdot}5 + x + \dfrac{W_f + W_c}{166{\cdot}6}}$$

Where the weight of 1 barrel of cement is 376 lbs.

$$x = \text{water cement ratio by volume} = \frac{\text{volume of mixing water}}{\text{volume of cement}}.$$

$0{\cdot}5$ = absolute volume of the solids in 1 cubic foot of loose cement.

W_f = weight of sand (fine aggregate) in lbs., used with one 94 lb. cu. ft. of cement.

W_c = weight of gravel (coarse aggregate) in lbs. used with one 94 lb. cu. ft. of cement.

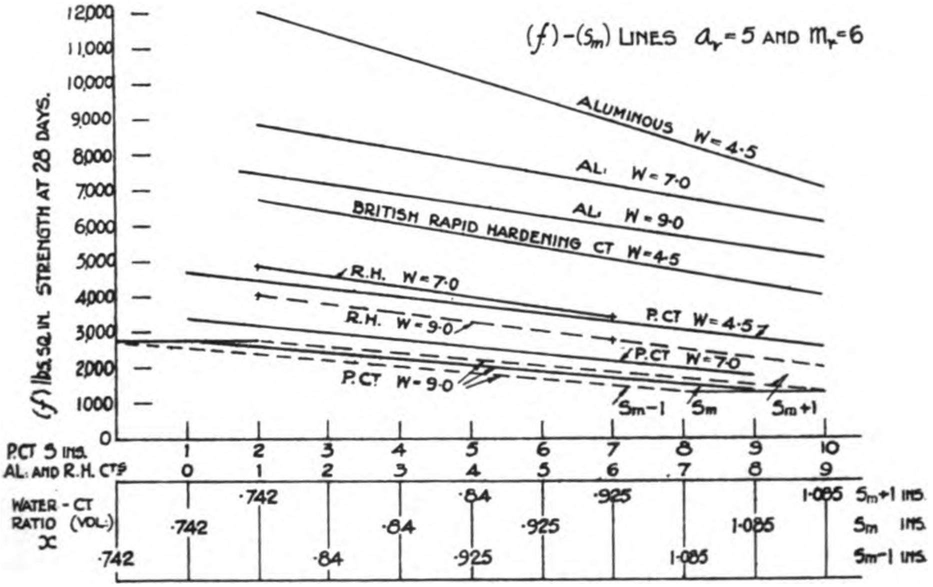

Fig. 3.

As the aggregate in this equation is given by weight, the following equation was developed to meet British practice, using volumes instead of weights and bags instead of barrels.

Bags of cement (of approximate 2½ cu. ft. capacity) per cu. yd. of concrete

$$= \frac{10{\cdot}8}{0{\cdot}5 + x + (0{\cdot}67 + 0{\cdot}018m_r)A_r} \qquad \text{(B)}.$$

$$\text{or, in American barrels of cement} = \frac{6{\cdot}75}{0{\cdot}5 + x + (0{\cdot}67 + 0{\cdot}018m_r)A_r} \quad . \quad . \ (1).$$

EXTRACT FROM TABLE 2 IN STANTON WALKER'S PAPER :

Mix by Volume (Real Mix).	Water Ratio.	Size.	Fineness Modulus (m_r).	Barrels Cement per cu. yd. of Concrete.		
				Calc. from Measured Yield.	By Stanton Walker's Equation.	By Equation 1
1–7	1·12	0–1½	5·75	0·95	0·95	0·96
1–4	1·09	0–1·4	3·05	1·48	1·55	1·50
1–4	0·86	0–¾	5·0	1·55	1·54	1·54
1–6	0·92	0–1½	5·75	1·12	1·12	1·11
1–4	0·95	0–⅜	3·5	1·52	1·58	1·54
1–4	0·96	0–⅜	4·0	1·55	1·56	1·52
1–3	0·68	0–1½	5·75	1·97	1·94	1·93

EXTRACTS FROM TABLE 1 IN STANTON WALKER'S PAPER :

Mix by Volume (Normal).	$A_r = \frac{7}{8}A_n$ (in case of Sand $C_n = 1$).	Water Ratio.	Grading.	m_r (from Duff Abrams' Tables).	Barrels of Cement per cu. yd. of Concrete.		
					Duff Abrams.	Stanton Walker.	Equation 1.
1–2·3	1–2·3	0·9	0–1·4	3 *assd.*	2·24	2·30	2·21
1–1·5–3·0	1–3·94	0·9	0–1″	5·44	1·56	1·57	1·53
1–2·3–4·2	1–5·7	0·9	0–3″	6·5	1·23	1·18	1·15
1–2·3–4·2	1–5·6 (C_n = ·86)	0·9	0–3″	6·5	1·23	1·18	1·17
1–1·4	1–1·4	0·7	0–1·4	3·0 *assd.*	3·18	3·14	3·07
1–0·7	1–0·7	0·56	0–1·4	3·0 *assd.*	4·36	4·41	4·32
1–1·3–2·8	1–3·58	0·8	0–1½	5·9	1·73	1·66	1·64
	1–3·52 (C_n = ·86)	0·8	0–1½	5·9	1·73	1·66	1·675

The figures from the Stanton Walker and No. 1 equations agree very well, showing that the shrinkage factor of 0·875 to 0·86 is a reasonable value.

The Straight-Line 28 Days Strength and Mean Slump Equation.

In *Figs.* 1 and 2 are given the relation between the strength of concrete and the water ratio, and also between the strength, slump, aggregate, and fineness modulus.

Professor Duff Abrams states that "with given concrete materials and condition of test the quantity of mixing water used determines the strength of the concrete so long as the mix is of a workable plasticity."

The equation expressing the relation he found to be of the form

$$f = \frac{C}{W^x}. \quad \text{(The strength-water ratio equation.)}$$

where f = compression strength of the concrete in lbs. per sq. in. at 28 days.
C = A number depending upon the cement.
W = A number depending upon the mixing and rigidity of control.

$$x \text{ water ratio by vol.} = \frac{\text{volume of mixing water}}{\text{volume of cement}}.$$

Minimum values of x—Ordinary Portland and rapid-hardening Portland cements—0·4;
„ „ „ Aluminous cement—0·7.

In *Fig.* 1, the curves A, B, C, and E are those for a cement having a value C of 14,000 with values of W equal to 9, 7, 5·85 and 4·5 respectively. Seven is the factor for average conditions; 9 the factor where rigid control is lacking; and in the paper presented by Messrs. Stanton Walker and Slater, a factor of 5·85 was obtained for a series of hand-mixed batches. During the actual work a value of $W = 4·5$ seems to have been obtained.

Curve D represents the $f - x$ equation for an aluminous cement, where C is equal to 36,000 and the factor W is 9. For a rapid-hardening Portland cement, C has the probable value of 20,000: see curves F and G (*Fig.* 1).

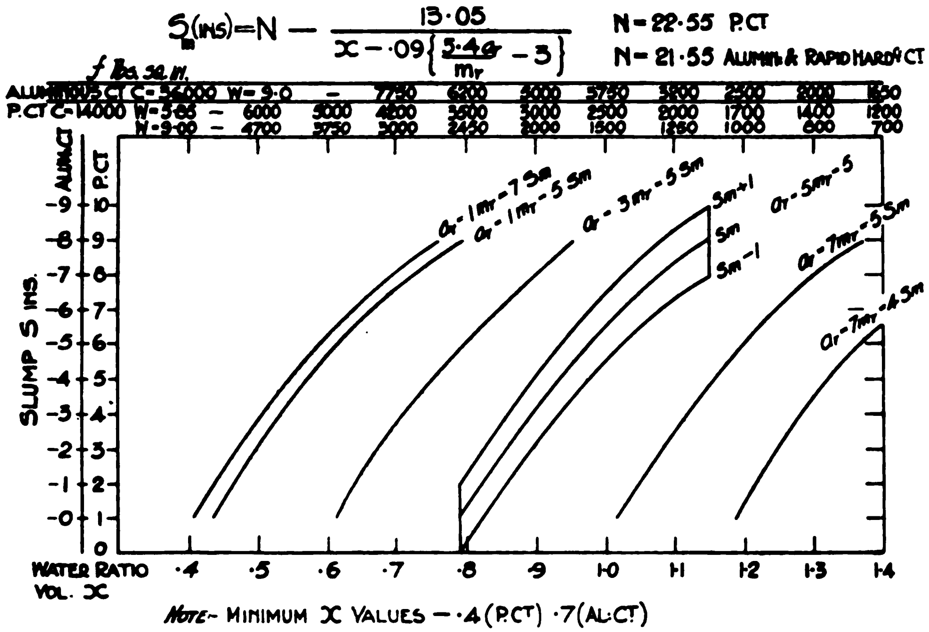

Fig. 4.

Let the mean slump in inches be represented by S_m ins. In *Fig.* 2 are given the stress, slump, and aggregate relations where the stresses are those for concrete having a value W equal to 9, and C equal to 14,000. The problem was to find some simple relation between these factors. A particular mix having a value of A_r and a fineness modulus m_r was taken. It was assumed that the ½-in. to 1-in.* slump range, be 0 to 2 inches, with a mean value of 1 inch: the 3-in. to 4-in. slump range to be 2 to 4 ins. with a mean of 3 ins.; the 6-in. to 7-in. slump to be 5 to 7 inches with a mean of 6 inches, and the 8-in. to 10-in. slumps to have a mean of 9 inches. Plotting the values of f against the corresponding mean slumps for the particular values of A_r and m_r, a straight-line graph resulted:

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* The range given by Prof. Duff Abrams on his curves corresponding to those of *Fig.* 2.

on plotting the $f - S_m$ (S_m again 1, 3, 6 and 9 ins.) values for other mixes, straight-line graphs again resulted. Finally an equation of the general form following was developed. This is

$$f = \left(\frac{C}{W^{x_0}} + 500m_r - 1{,}000A_r + 50A_r^2\right)\{(1 + b) - bS_m\}.$$

where x_0 is a value depending upon C, and b is a constant depending upon W and C.

The equation containing x_0 and C is

$$\frac{C}{9^{x_0}} - \frac{C}{9^{\cdot 7}} = 500.$$

Knowing C, x_0 can be found.

When $S_m = 1$ in.

$$f = \left(\frac{C}{W^{x_0}} + 500m_r - 1{,}000A_r + 50A_r^2\right) = f_1 \text{ lbs./sq. in.}$$

where f_1 is the compressive strength at 28 days for a 1-inch slump.

Let $C_W = \dfrac{C}{W^x}$.

	C	x_0	W	b	C_W
American Portland cement (used by Prof. Duff Abrams)	14,000	0·63	9	0·066	3,500
	14,000	0·63	7	0·0634	4,150
	14,000	0·63	5·85	0·058	4,600
	14,000	0·63	4·5	0·052	5,450
Rapid Hardening Portland cement (probable values)	20,000	0·65	9	0·066	4,800
	20,000	0·65	7	0·0638	5,940
	20,000	0·65	4·5	0·0525	7,520
Aluminous cement (probable values)	36,000	0·68	9	0·066	8,200
	36,000	0·68	7	0·0644	9,000
	36,000	0·68	5·85	0·0583	10,820
	36,000	0·68	4·5	0·0533	12,000

The base for the work was the equation $f = \dfrac{14{,}000}{9^x}$.

Using the $f - S_m$ equation for $C = 14{,}000$, $W = 9$, $x_0 = \cdot 63$, the following table was obtained.

S_m ins.	1	3	6	9
f lbs./sq. in. @ 28 days	3,000	2,600	2,000	1,400
x (vol. ratio)	·7	·77	·886	1·05

Using the equation $f = \dfrac{36{,}000}{9^x}$ for aluminous cement when

x	·7	·77	·886	1·05
f lbs./sq. in. @ 28 days	7,700	6,650	5,150	3,600

It has been assumed in the above that the unit weight and volume of aluminous cement is the same as that for the American Portland cement, and that the same mixes will slump the same for the same amounts of water whether mixed with American cement or aluminous cement.

Using the $f - S_m$ equation developed for aluminous cement, where $C = 36{,}000$, $W = 9$ and $x_0 = \cdot68$,

x	·7	·77	·886	1·05
f lbs./sq. in.	7,750	6,680	5,180	3,620
S_m ins.	1	3	6	9.

the values of f agreeing very well with those from the $f = \frac{C}{W^x}$ equation.

To test the slump assumption an experiment was carried out on a mix of 1 of aluminous cement to 4·7 (A_r) of sand and gravel, having a fineness modulus of $m_r = 5{\cdot}2$. For a Portland cement concrete of the same proportions the $S—x$ curves of $(S_m + 1)$ ins., S_m and $(S_m - 1)$ inches were drawn (see par. dealing with the slump-water ratio curve). With x values of ·8, ·9, 1·0 and 1·1, the slump values obtained all came within the (S_m) and $(S_m - 1)$ curves drawn: chiefly inclining to the $(S_m - 1)$ curve. This appears to show that a Portland cement concrete slumps more than a similar aluminous cement concrete for the same x value. The $(S_m - 1) - x$ curve for the Portland cement concrete has been taken as being the $(S_m) - x$ curve for the similar mix of aluminous cement concrete. Therefore the $(f) - (S_m)$ equation for aluminous cement concrete will

read $$f = \left(\frac{36{,}000}{W^{0{\cdot}68}} + 500m_r - 1{,}000A_r + 50A_r^2\right)\{(1 + b - b(S_m + 1)\}.$$

Similarly for a rapid-hardening cement concrete for S_m in the $f - S_m$ equation read $(S_m + 1)$.

The value of b was found by trial to be 0·066 for a value of W equal to 9. For other values of W, b was found from the equation

$$b = \cdot066\left(\frac{9}{W}\right)^{\frac{x_0}{9-W}}\frac{\log_e W}{\log_e 9}.$$

In the case of aluminous cement, x must not be less than 0·7, giving a limiting value of f equal to $\frac{36{,}000}{9^{\cdot7}}$.

The limits for the use of the $f - S_m$ equations are

$A_r = 7{\cdot}5$ (working between values of $m_r = 4{\cdot}0$ and $7{\cdot}0$)
and $A = 1{\cdot}0$ „ „ „ „ $= 4{\cdot}0$ and $9{\cdot}0$),

m_r 4·0 to 9 0 being practical figures for concrete in practice; the corresponding strengths for the American Portland cement being 1,500 to 4,000 lbs. sq. in.

In *Fig.* 3 are plotted $(f) - (S_m)$ lines for C 14,000, 20,000 and 36,000, $A_r = 5$, $m_r = 6$, $W = 9$, 7, and 4·5.

In the case of $C = 14{,}000$, $W = 9$, three lines have been drawn, a, $(f) - (S_m)$, b, $(f) - (S_m + 1)$ and c, $(f) - (S_m - 1)$.

It will be noticed that curve "a" commences at $S = 1$ inch, "b" at $S = 2$ inches and "c" at $S = 0$. Also that the line $(f) - (S_m + 1)$ or curve "b" has been moved 1 inch to scale to the right and that the line $(f) - (S_m - 1)$, or curve "c" has been moved 1 inch to scale to the left. The strength points then for $A_r = 5$, $m_r = 6$, $W = 9$ will then probably lie between the lines $(f) - (S_m - 1)$ and $(f) - (S_m + 1)$.

In *Fig* 2 are also given the relations between the real volume of the aggregate, its fineness modulus and the maximum size of stone in the aggregate.

The maximum size of the aggregate is the next largest size to that which will retain at least 15 per cent.; that is, if 15 to 16 per cent. were retained on the ⅜-in. sieve, the maximum size would be ¾; if only 14 per cent. were retained the maximum size would be ⅜ in.

Let G be the maximum size of aggregate, then an equation connecting m_r, A_r and G is of the form

$$\log m_r = (0{\cdot}762 - 0{\cdot}0075A_r)G^{(0{\cdot}151 - 0{\cdot}0155G)}.$$

Above $A_r = 7{\cdot}5$ it would appear that f_1 would become of the form

$$f_1 = \left(\frac{C}{W^{x_0}} + 500m_r - 1{,}000A_r + 50A_r^2 - 3{\cdot}25A_r m_r\right).$$

The Slump–Water Ratio Equation.

From a consideration of the strength–mean slump and the strength–water ratio equations, an equation connecting the mean slump and water ratio was developed. This is found to be, for Portland cement concrete,

$$S_m \text{ ins.} = 22{\cdot}55 - \frac{13{\cdot}05}{x - 0{\cdot}09\left(\dfrac{5{\cdot}4A_r}{m_r} - 3\right)}.$$

For rapid-hardening Portland cement and aluminous cement concretes, it would appear that 22·55 should read 21·55 (see remarks on aluminous concrete slump tests in the previous paragraphs). In *Fig.* 4, using this equation, have been drawn the slump–water ratio curves for $A_r = 1$ to 7 for a value of $m_r = 5$ also for $A_r = 1$ $m_r = 7$. In this case it will be noticed that the curve has moved slightly to the left of that for $m_r = 5$. The curve $A_r = 7$ $m_r = 4$ has also been drawn showing that a decreasing value of m_r throws the curve towards the right. The limits of S_m are 1 to 9 ins. From a study of the curves it can be seen at a glance the range of the x values for the particular values of A_r and m_r.

To indicate the probable strength values, additional scales to the top of the graph have been given. They are for values of $C = 14{,}000$ and 36,000, and $W = 9{\cdot}0$ and 5·85 respectively. They have been calculated from the strength-water ratio equation for the values of x concerned.

As the fineness modulus value affects the slumping it would therefore appear that the fineness of the cement also affects the slump. Therefore a rapid-hardening cement concrete should require a greater water ratio for a given slump than a corresponding Portland cement concrete.

An Analysis of the test results of the 1 : 2·4 : 3·6 *Newark Bay Field Mix given by Messrs. W. A. Slater and Stanton Walker in their paper to the American Society of Civil Engineers.*

From the data given in the paper the 1 : 2·4 : 3·6 field mix had an apparent real value of A_r varying from 4·5 to 4·7 with values of m_r from 5·6 to 5·92 respectively. The fineness modulus of the sand used varied from 2·45 to 3·21, with a mean of 2·76, and that of the gravel from 6·15 to 7·70, with a mean of 7·37. The water content of the sand varied from 3·8 to 5·1 per cent. In *Fig.* 5 the mean slump–water ratio curves have been plotted for $A_r = 4{\cdot}5$ ($m_r = 5{\cdot}6$) and $A_r = 4{\cdot}7$ ($m_r = 5{\cdot}92$).

The curves representing the ± 1 inch allowance have also been plotted. Also the $S - x$ points from the actual tests have been plotted It will be noticed that only about half the test points lie between the highest and lowest of the $S_m - x$ curves drawn. This indicates that the value of A_r must have been varying during the test. It has been assumed that the aggregate measurements were constant and consequently m_r and that the cement volume had been varying slightly. Consequently a curve of $S_m - x$ with the + 1 inch allowance has been drawn for $A_r = 4$ ($m_r = 5{\cdot}92$) and a curve of $S_m - x$ with the − 1 inch allowance for $A_r = 5{\cdot}6$ ($m_r = 5{\cdot}6$). Between these two new curves the majority of the test points lie.

A value of $A_r = 4$ corresponds to a field mix of $1{\cdot}17 : 2{\cdot}4 : 3{\cdot}6 = 1 : 2{\cdot}0 : 3{\cdot}0$ (very nearly) and a value of $A_r = 5{\cdot}6$ corresponds to a field mix of

$$0{\cdot}8 : 2{\cdot}4 : 3{\cdot}6 = 1 : 3{\cdot}0 : 4{\cdot}5$$

Nominally 5 bags of cement were used per batch, but the values of $A_r = 4{\cdot}0$ and 5·6 correspond respectively to a use of 6 and 4 bags per batch respectively.

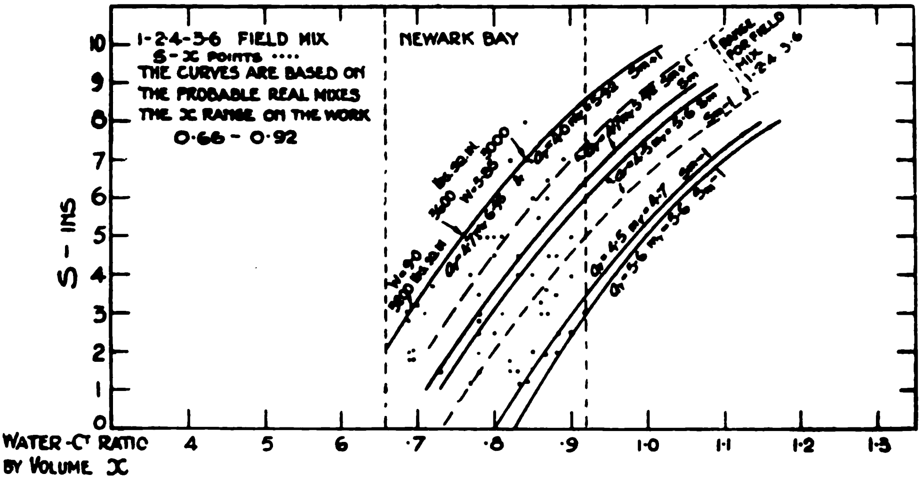

Fig. 5.

Assuming again $A_r = 4{\cdot}7$ to $4{\cdot}5$ remained constant: what should be the new values of m_r, so that the test points all lay within the theoretical curves?

Working from the test points and allowing a + 1-inch slump for the value of $A_r = 4{\cdot}7$, it was found that to get the maximum $S_m - x$ curve to cover the majority of the points, m_r should be equal to 6·95. Also, to find the lowest curve to include the test points the − 1 inch was allowed for $A_r = 4{\cdot}5$ and a value of $m_r = 4{\cdot}7$ was obtained.

Now if m_r is varying, this indicates a change in the grading of the aggregates used. m_r 6·95 indicates a change to a large aggregate and $m_r = 4{\cdot}7$ indicates a change to a smaller aggregate. But as the value of m for the gravel only varied from 6·15 to 7·70 and the water content of the sand 3·8 to 5·1 per cent. this seems to indicate that m_r did not vary, but there was a variation in the cement content.

A further calculation indicates, too, that the maximum value of m_r was 6·05 for a value $A_r = 4·60$.

In *Fig.* 1 have also been plotted the $f - x$ values for the Newark Bay tests: the points appear to lie mainly between two curves of the values $f = \frac{14{,}000}{9^x}$ and $\frac{14{,}000}{4·5^x}$. This indicates a great variability in the mixing and rigidity of control.

In *Fig.* 6 have been plotted the $f - S$ points for the Newark Bay tests. On this figure have also been plotted the following straight lines.

$f - S_m$ line for $A_r = 4·0$ $m_r = 5·92$, $W = 4·5$.
$f - (S_m + 1$ inch) line do.
$f - S_m$ line for $A_r = 5·6$ $m_r = 5·6$ $W = 9·0$.
$f - (S_m - 1)$ line do.
$f - (S_m + 1)$ line for $A_r = 4·7$ $m_r = 6·95$, $W = 4·5$.
$f - (S_m + 1)$ line for $A_r = 4·7$ m_r do.
$f - (S_m - 1)$ line for $A_r = 4·5$ $m_r = 4·7$, $W = 9·0$.

It will readily be seen that the $f - S$ test points lie between the lines $(f) - S_m$ and $(S_m + 1)$ for $A_r = 4·7$ $m_r = 5·92$ $W = 4·5$, and $A_r = 5·6$ $m_r = 5·6$ $W = 9·0$.

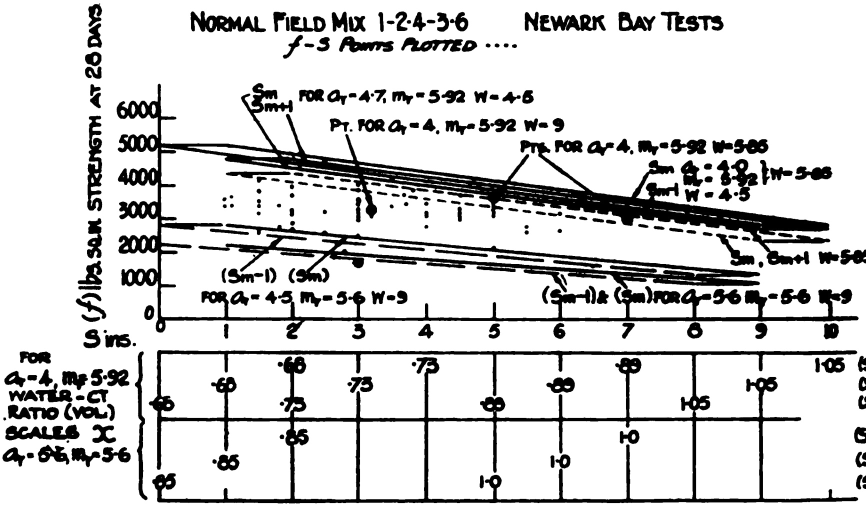

Fig. 6.

The lines for $A_r = 4·7$, $m_r = 6·95$, $W = 4·5$ lie well above those of $A_r = 4·7$, $m_r = 5·92$ and lie well outside the points plotted; this would again indicate that the cement volume was varying and not the aggregates.

It is interesting to note that the lines $(f) - (S_m)$ and $(f) - (S_m + 1)$ for $A_r = 4·0$ $m_r = 5·92$, $W = 5·85$, lie within the lines stated. Yet they include two points whose aggregates are probably of the value $A_r = 4·0$ $m_r = 5·92$. This is known from the experimental data.

An analysis of these test figures therefore clearly indicates the difficulty of fixing the value of W during the mixing periods: it also shows that control must be rigid—that grading should be watched—that the cement should be gauged by gauge boxes as for the aggregates and not by bags or barrels. How should therefore the mixing of concrete be specified in practice?

The Specifying of Concrete by the Water Cement Ratio Theory and the Equations developed.

It must be assumed W to vary between wide limits: let these limits be, say, 9 and 5·85.

From a knowledge of the aggregates to be used a value of A_r can be ascertained either by actual test or by the use of the constants C_n and C_f: in the latter case assume the moisture content of the sand 5 per cent. Any change then in the moisture content of the sand will increase the value of A_r and decrease the value of m_r. To cover a slight variation in A_r and m_r allow, say, a ± 10 per cent. variation in the cement content per batch—this will cause A_r to vary from $\frac{10}{11}A_r$ to $\frac{10}{9}A_r$, m_r remaining the same. A value of C must also be assumed for the cement.

(*A*) *A Working mean Slump being Required.* (See *Fig.* 7.)

On an $S_m - x$ graph draw the $(S_m + 1) - x$ curve for the $\frac{10}{11}A_r$ m_r mix and the $(S_m - 1) - x$ curve for the $\frac{10}{9}$ $A_r m_r$ mix. On this graph plot corresponding strength scales for the mixes $\frac{10}{9}{}_r$. $W = 9$ and $\frac{10}{11}A_r$. $W = 5{\cdot}85$. Graphs have been drawn in *Fig.* 7 for a basic value of $A_r = 5$ $m_r = 6$.

How to Use the Graphs obtained.

Let S_m be, say, 5 inches. Then S ins. can vary between 4 and 6 inches. Draw lines for 4 and 6 inches to cut the $S - x$ curves for the $\frac{10}{11}A_r$ and $\frac{10}{9}$ A_r mixes. Let the points of intersection be *a,b,c,d*.

Now corresponding to points *abcd* the values of x can be obtained and consequently the allowable range for x during the working period: also corresponding to *abcd* the probable strengths can be found from the two strength scales given. Averaging the strengths obtained the probable mean strength of the concrete made during the work will be found. Therefore in practice specify the number of bags required per cubic yard of concrete—with an allowable variation of ± 10 per cent. State the allowable water range for a slump range of n inches, stating the mean value. During the work the $S - x$ points obtained should lie within the area *abcd* as indicated on the graph, *Fig.* 7. If they lie outside this area then the factors should be varied as indicated in *Fig.* 7. State the probable mean strength value for the concrete.

(*B*) A_r and m_r known, *Specifying the Probable mean strength required* (see

Fig. 8). It is required in this case to find the mean slump or the slump range. Suppose $C = 14{,}000$. Draw the $f - (S_m + 1)$ inch lines for a value of $\frac{10}{9} A_r$ $W = 5{\cdot}85$ and the $f - (S_m - 1)$ inch lines for a value of $\frac{10}{11} A_r$, $W = 9{\cdot}0$; m_r being as determined. This has been done in *Fig.* 8 for a basic value of $A_r = 5$, $m_r = 6{\cdot}0$.

Suppose a mean strength of 2,500 lbs. per sq. in at 28 days is required. Draw the line $f = 2{,}500$ lbs. per sq. in line to cut the $f - S$ lines for the mixes of $\frac{10}{9}$ and $\frac{10}{11} A_r$ as drawn. Let these points be X.Y. It is required to find a shaded strip ABCD, such that the area above the $f = 2{,}500$ line is practically equal to that below. The slump range and the mean slump are thus found. On a $S - x$ graph, the required shaded test area can now be drawn for the slump range found, proceeding as given in (*A*).

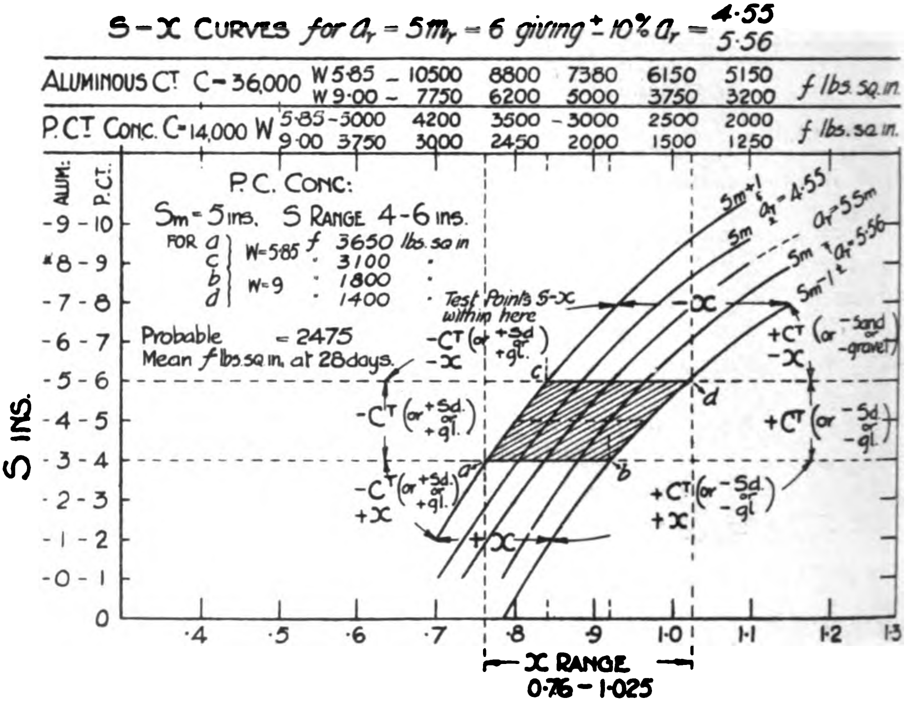

Fig. 7.

This method of specifying by the water-cement ratio theory is due to the number of variables which can come into play; these are C, W, A_r, m_r, and x. A_r, m_r and x can be determined on the work; C must be assumed, and it can be assumed more or less correctly, but W cannot be known until the actual crushing tests for strength have been carried out. Thus its value must be treated as indicated in the paper.

It may be considered that the ± 10 per cent. allowable variation in the cement content is too high: if so an allowance of ± 5 per cent. or other lower figure can be taken and the calculations proceeding along the lines indicated.

In *Figs.* 7 and 8 have also been drawn the strength-slump lines for a corresponding aluminous cement concrete: the working strength required being

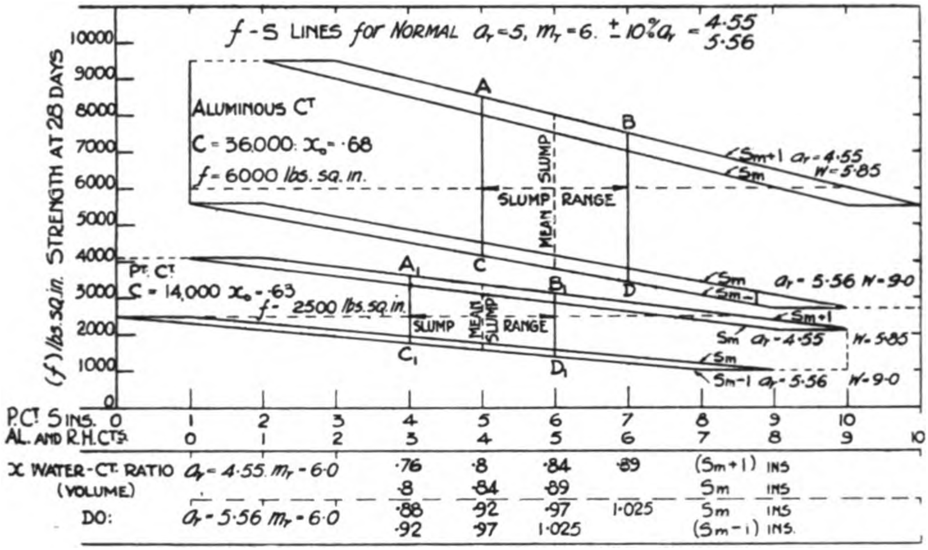

Fig. 8.

6,000 lbs./sq. in at 28 days: the economical mean slump was again found to be 5 inches, the slump range being 4 to 6 inches.

Note that in practice when allowing for the water to be added to the batches for mixing purposes, the water content of the aggregates must be allowed for. For example, see the following table: sand, water content 5 per cent.; gravel, water content, 2½ per cent. Strength based on the $\frac{14{,}000}{9^x}$ curve.

Field Mix.	f lbs./sq. in.	x (Dry Materials).	x allowing for the Water Content.	Galls. of Water per Bag of Cement.	Slump in Ins.		
1–2–4	2,000	·20	·58	9·25	m_r 5·0	5·8	6·6
					S_m 4·0	5·5	6·9
1–2–3	2,200	·85	·57	9·25			
1–1½–3	2,400	·80	·56	9·25			
1–1–2	2,600	·75	·59	9·25	m_r 5·25	6·05	6·85
					S_m 6·6	7·5	8·2

Allowance should be made for the water which will be absorbed by the aggregate, average figures of which are as follows:—

Average sand, pebbles, crushed limestone .	1	per cent. by weight.
Trap and granite	0·5	,, ,,
Porous sandstone	7·0	,, ,,
Very light and porous aggregate up to .	25·0	,, ,,

DATA FOR PRICING REINFORCED CONCRETE.*

MATERIALS DELIVERED 4 MILES FROM CHARING CROSS.

		s.	d.
Best Washed Sand	per yard	13	6
Clean Shingle, ¾ in. mesh	,,	12	6
,, ,, ½ in. mesh	,,	13	6
Thames ballast	,,	10	6
Broken brick (¾ in.)	,,	11	6
Best British Portland Cement (delivered London area).	per ton 53s. to	55	0
Rapid-Hardening Portland Cement	delivered London 10s. per ton extra		
"Super-Cement"	per ton 83s. to	88	0
"Lightning" Brand Aluminous Cement	,, 100s. to	105	6
Ciment Fondu	works f.o.r.	95	0

Boarding for Shuttering—

		Sawn. s.	d.	*Wrot.* s.	d.
1 in.	per square	23	6	27	6
1¼ in.	,,	29	6	33	6
1½ in.	,,	35	6	41	0

Sawn Timber for Struts and Supports—

3 in. by 4 in.	from £22 per standard
3 in. by 6 in. and 3 in. by 7 in.	,, £20 ,, ,,

Mild Steel Rods for Reinforcement—

		s.	d.
⅝ in. to 2⅞ in. Rounds	per cwt.	10	6
7/16 in. to ½ in. Rounds	,,	10	9
⅜ in. Rounds	,,	11	0
¼ in. Rounds	,,	12	0

Breeze Slabs per yd. super: 2 in., 1/11; 2½ in., 2/4; 3 in., 2/9; 4 in., 3/6.

MATERIAL AND LABOUR, INCLUDING 10 PER CENT. PROFIT.

(*Based on Contracts up to £2,000.*)

Portland Cement Concrete well mixed in proportion 1 : 2 : 4—

		s.	d.
Do. do. in foundation	per foot cube	1	9
Do. do. in columns	,, ,,	1	11
Do. do. in beams	,, ,,	2	1
Do. do. in floor slabs 4 in. thick	per yard super	5	6
Do. do. in floor slabs 5 in. thick	,, ,,	7	0
Do. do. in floor slabs 6 in. thick	,, ,,	8	6
Do. do. in floor slabs 7 in. thick	,, ,,	9	10
Do. do. in walls 6 in. thick	,, ,,	8	2

(*Add for hoisting* 3s. 6d. *per yard cube above ground-floor level. Add for "Ferrocrete"* 1s. 10d. *per yard cube.*)

Steel Reinforcement, including Cutting, Bending and putting into Position and securing with Stout Binding Wire—

		s.	d.
From ¼ in. to ⅜ in.	per cwt.	22	6
,, 7/16 in. to ½ in.	,,	21	6
,, ⅝ in. to 2⅞ in.	,,	20	6

EXTRA LABOUR TO BENDS in ¼-in. rods, ½*d.*; ⅜-in. rods, 1*d.*; ½-in. rods, 1¼*d.*; ⅝-in. rods, 1½*d.*; ¾-in. rods, 1¾*d.*; ⅞-in. rods, 2*d.*; 1-in. rods, 2¼*d.*; 1⅛-in. rods, 3*d.*; 1¼-in. rods, 3½*d.*; 1⅜-in. rods, 4½*d.*; 1½-in. rods, 6*d.* (per bend per cwt.).

EXTRA LABOUR TO HOOK BENDS: ¼ in., 1*d.*; ⅜ in., 2*d.*; ½ in., 2½*d.*; ⅝ in., 3*d.*; ¾ in., 3½*d.*; ⅞ in., 4*d.*; 1 in., 4½*d.*; 1⅛ in., 6*d.*; 1¼ in., 7*d.* (per bend per cwt.).

Shuttering—

		s.	d.
Shuttering and Supports for Concrete Walls (both sides measured)	per square	59	0
Centering to Soffits of Reinforced Concrete Floors and Strutting, average 10 ft. high	per square	55	0
Do. do. in small quantities	per ft. super	0	10
Shuttering and Supports to Stanchions for easy removal, average 18 in. by 18 in.	per ft. super	0	11½
Do. do. as last, in narrow widths	,, ,,	1	1½
Do. do. to sides and soffits of beams, average 9 in. by 12 in.	,, ,,	1	1¼
Do. do. as last, in narrow widths	,, ,,	1	3½
Raking, cutting, and waste to shuttering	per ft. run	0	3
Labour, splay on ditto	,, ,,	0	2
Small angle fillets fixed to internal angles of shuttering to form chamfer	,, ,,	0	3

WAGES.—The rates of wages on which the above prices are based are:—Carpenters and joiners, 1/9½ per hour; Carpenters working on old shuttering, 1/10½; Labourers on building works, 1/4½; Men on mixers and hoists, 1/5½; Bar-benders, 1/5½.

[* This Data is specially compiled for *Concrete and Constructional Engineering*, and is strictly copyright.]

Prospective New Concrete Work.

Accrington.—*Reservoir.*—The Accrington District Gas & Water Board is preparing a scheme for the construction of a covered reservoir.

Acle.—*Bridge.*—The Eastern Highways Committee of the Norfolk C.C. is seeking advice on the proposal to erect a bridge at Acle.

Annfield Plain.—*Road.*—The U.D.C. proposes to construct a road from Delight Bank to the St. John's housing estate at Dipton.

Barmouth.—*Sea Defence Works.*—The U.D.C. is seeking permission to spend £20,000 on sea defence work.

Blackwood.—*Houses.*—The Bedwellty U.D.C. has applied for permission to build 120 houses at Blackwood.

Braintree. — *Water Tower.* — The U.D.C. has applied for sanction to borrow £4,076 for the construction of a water tower.

Bushbury. — *Road.* — The Cannock R.D.C. proposes to spend £12,000 on the construction of a by-pass road to connect Park Village, Heath Town, with the main road from Wolverhampton to Stafford.

Charlwood.—*Bridge.*—The Reigate R.D.C. has applied for a grant towards the cost of constructing a bridge over the Mans Brook, Charlwood.

Chepstow.—*Road.*—The U.D.C. is considering a scheme for the construction of a road through the town to the footbridge.

Coleraine. — *Concrete Road.* — The U.D.C. proposes to spend £2,540 on reconstructing Strand Road in reinforced concrete.

Colne.—*Houses.*—The T.C. is seeking permission to build 52 houses on the Birtwistle Avenue site.

Coventry. — *Reservoirs.* — The City Council proposes to construct service reservoirs at Coundon, Meriden Ridge, and Corley, and water towers near Earlsdon and Tile Hill.

Coulsdon.—*Bridge.*—The Coulsdon & Purley U.D.C. is considering a scheme for the provision of a bridge at Foxley Hill Road.

Croydon.—*Concrete Wall.*—A reinforced concrete wall is to be constructed at the Mitcham Road Cemetery. The cost is estimated at £2,250.

Edinburgh.—*Bridges.*—Two bridges are to be erected on the main Edinburgh-Glasgow Road at Blackhall.

Esher.—*Road.*—The U.D.C. has instructed the Surveyor to prepare plans for the construction of a road from Batchelor's Hill to the Esher boundary.

Glasgow. — *Concrete Cottages.* — The T.C. proposes to erect 1,000 concrete cottages at a cost of £390 each.

Goole.—*Houses.*—The U.D.C. has instructed the Surveyor to prepare plans for the construction of 50 houses.

Greenwich (London).—*Houses.*—The B.C. is seeking sanction to borrow £36,176 for the construction of 76 houses at Charlton Park.

Guildford.—*Houses.*—The Housing Committee is considering a scheme for the erection of 24 houses and 80 flats on the Aldershot Road estate.

Hamworthy. — *Piling.* — The Poole Harbour Commissioners have under consideration the question of piling repairs at the Commissioners' Wharf. The cost is estimated at £5,000.

Hayes.—*Houses.*—The U.D.C. proposes to erect 50 houses.

Heanor.—*Houses.*—The U.D.C. proposes to build 120 houses.

Hury. — *Bridge.* — The Startforth R.D.C. is considering a proposal to erect a bridge over the Howgill Beck.

Kells.—*Houses.*—The Whitehaven T.C. proposes to build 54 houses by direct labour. The cost is estimated at £340 each.

Kirkcaldy.—*Houses.*—The T.C. proposes to build 144 houses.

Leslie.—*Houses.*—The T.C. is considering a scheme for the construction of 40 houses on the Maryfield site.

Limerick. — *Concrete Pavilion.* — The Garryowen Football Club proposes to build a reinforced concrete pavilion at Market Fields.

Littlehampton.—*Concrete Road.*—A 20-ft. concrete road is to be constructed at Wick, at an estimated cost of £4,800.

Llandovery.—*Bridge.*—The Carmarthenshire Main Roads and Bridges Committee has agreed to build a bridge at Pontrhydowen, Llandovery.

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LONDONDERRY.—*Houses.*—The Corporation Finance Committee is seeking sanction to borrow £40,000 for housing purposes.

ORSETT.—*Houses.*—The R.D.C. has applied for sanction to erect 200 houses.

PERTH.—*Houses.*—The Housing Committee has recommended the T.C. to build 150 houses.

ROSS. — *Houses.* — The U.D.C. has applied for permission to build 50 houses at Redhill.

SCARBOROUGH. — *Promenade.* — The T.C. has applied for sanction to borrow £12,370 for reinforced concrete work in connection with widening a portion of Spa Grounds and South Cliff gardens.

SHAW. — *Houses.* — The Crompton U.D.C. proposes to erect 50 houses in the Shaw district.

SOWERBY.—*Houses.*—The U.D.C. proposes to build 50 houses on the Beechwood estate.

STOURPORT.—*Promenade.*—The U.D.C. proposes to construct a 10-ft. promenade along the river bank for a distance of about 400 yards.

VENTNOR.—*Groynes.*—The U.D.C. has applied for sanction to borrow £1,000 for the construction of groynes on the Eastern Esplanade.

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WARRINGTON.—*Concrete Bridge.*—The Manchester Ship Canal Co. proposes to erect a reinforced concrete bridge over Moore Lane, near Warrington.

YIEWSLEY.—*Houses.*—The U.D.C. has applied for permission to build 250 houses.

Tenders Accepted.

BERRYDEN.—*Concrete Water Tower.*—The Northern Co-operative Society, Ltd., have accepted the tender of Messrs. Clark & Chapman, Aberdeen, for the construction of a reinforced concrete water tower.

COATBRIDGE.—*Concrete Floors.*—The Lanarkshire Education Authority has accepted the tender of Messrs. Loudon & Inglis, Coatbridge, at £4,480, for the construction of concrete floors at the technical school.

FOYNES. — *Concrete Culvert.* — The Foynes Harbour Board has accepted the tender of Messrs. T. H. Bramall & Son, Limerick, at £943, for the construction of a reinforced concrete culvert at the harbour entrance.

FRIMLEY GREEN.—*Concrete Houses.*—The Frimley U.D.C. has accepted the tender of Mr. Renn, Frimley Road, Camberley, at £3,178, for the construction of 8 concrete houses.

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FRINTON-ON-SEA.—*Concrete Sea Wall.*—The U.D.C. has accepted the tender of Messrs. May, Gurney & Co., Ltd., at £3,193, for the construction of a reinforced concrete sea wall. Other tenders submitted: J. L. Emery & Co., £3,515; W. Green & Sons, £3,615; T. Wilkinson & Co., £3,949; E. Kearton & Partners, £4,211; G. Wimpey & Co., Ltd., £4,250; Middleton & Keene, Ltd., £4,377; W. & C. French, £4,510; F. Mitchell & Son, Ltd., £4,775; A. E. Farr, £5,002; J. Shelbourne & Co., Ltd., £5,388.

GLASGOW.—*Concrete Bunker.*—The Corporation has accepted the tender of Messrs. Gray's Ferro-Concrete Co., Ltd., at £4,799, for the construction of a reinforced concrete bunker.

IPSWICH.—*Concrete Bridge.*—The T.C. has accepted the tender of Messrs. Stewart & Partners, at £2,885, for the construction of a reinforced concrete bridge.

LANGHAM.—*Concrete Bridge.*—The Rutland C.C. has accepted the tender of the Reinforced Concrete Construction Co., for the reconstruction of Langham Bridge.

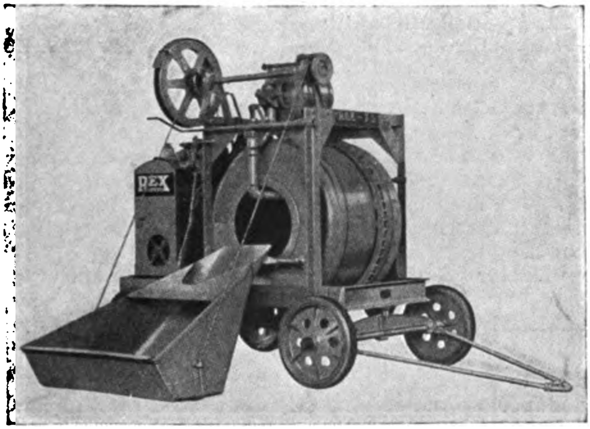
LEWISHAM (LONDON).—*Concrete Road.*—The B.C. has recommended for acceptance the tender of Mr. J. W. Adams, at £1,891, for the construction of a concrete road in Arthurdon Road.

NEWENT. — *Concrete Bridge.* — The R.D.C. has accepted the tender of Messrs. Hobrough & Co., Ltd., Gloucester, at £792 2*s.* 4*d.*, for the construction of a reinforced concrete bridge at Ketford. Other tenders submitted: Johnson's Reinforced Concrete Engineering Co., Ltd., £1,560; James Joiner & Co., Ltd., £1,552 10*s.* 8*d.*; A. E. Farr, London, £1,100; W. A. Porter, Derby, £1,042 10*s.* 10*d.*

POOLE.—*Concrete Groyne.*—The Harbour Board has accepted the tender of Messrs. J. Howard & Co., at £245, for the construction of a concrete groyne.

SOUTHAMPTON.—*Concrete Road.*—The Corporation has accepted the tender of Messrs. H. Osman & Co., Ogle Street, Southampton, at £2,675, for reconstructing Knighton Road in reinforced concrete.

SUDBURY.—*Concrete Bridge.*—The Mid-



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dlesex C.C. has accepted the tender of Messrs. Peter Lind & Co., at £12,845, for the construction of a reinforced concrete bridge over the Metropolitan District Railway at Sudbury.

TOTTENHAM (LONDON). — *Concrete Houses.*—The U.D.C. has accepted the tender of Messrs. John Laing & Son, Ltd., Mill Hill, N.W., at £57,059, for the construction of 110 concrete houses on the White Hart Lane estate.

WIMBLEDON (LONDON).—*Tea Chalet.*—The B.C. has accepted the tender of Messrs. Christiani & Nielsen, at £1,308 10*s*. 7*d*., for the construction of a tea chalet in Wimbledon Park.

British Portland Cement Association.

THE British Portland Cement Association has recently opened new branch offices in the provinces. The various addresses of the Association are now as follows:

Head Office.—20 Dartmouth Street, London, S.W.1.
South-Western Counties.—68 Queen's Square, Bristol.
South Wales Area.—59 Queen Street, Cardiff.
Midlands.—21 Waterloo Street, Birmingham.
North-Eastern Counties.—New Street Chambers, York.
North Wales and North-Western Counties.—41 John Dalton Street, Manchester.
Scotland.—63 George Street, Edinburgh.
Ireland.—14 Dawson Street, Dublin.

Trade Notices.

New Cement Works.—Messrs. G. & T. Earle, Ltd., are about to erect a large cement works near Hope, Derbyshire. The works will be about 14 miles from Sheffield 25 miles from the centre of Manchester, and will also serve the Chesterfield, Barnsley and Potteries area. The Hope Valley is one of the most beautiful districts in England and precautions are being taken to ensure that it will not be spoiled. The works are to be placed at a distance from the main road, and the appearance of the plant will be made as attractive as possible. Owing to the closing down of a neighbouring works there is considerable unemployment in the Hope Valley, and it is anticipated that the new works will add to the prosperity of the district. Electric power will be used for driving the plant, and electricity will also be made available in the villages near the works.

"**Rooshors,**"—We are asked to bring the notice of our readers to an erroneous statement contained in the announcement of Messrs. Cowan Hulbert Ltd., of Abbey House, Victoria Street, Westminster, S.W.1, in last month's issue. It was stated that the number of self-lock adjustable "Rooshors" in use in the London area was over 1,000. This should, of course, have been 10,000.

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CONSTRUCTIONAL ENGINEERING

DECEMBER 1927 VOL. XXII No. 12

TWENTY-SECOND YEAR OF PUBLICATION

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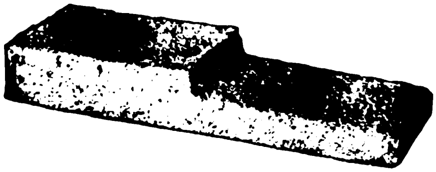

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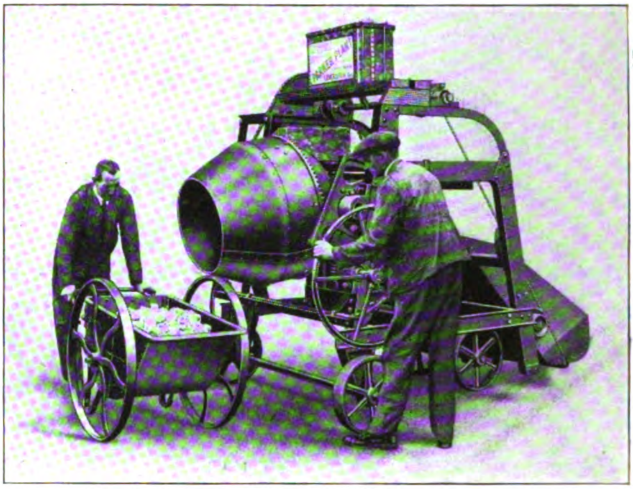

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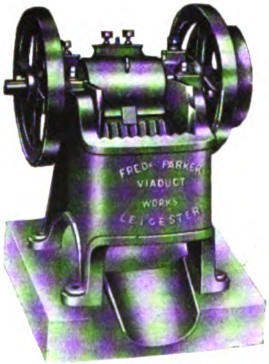

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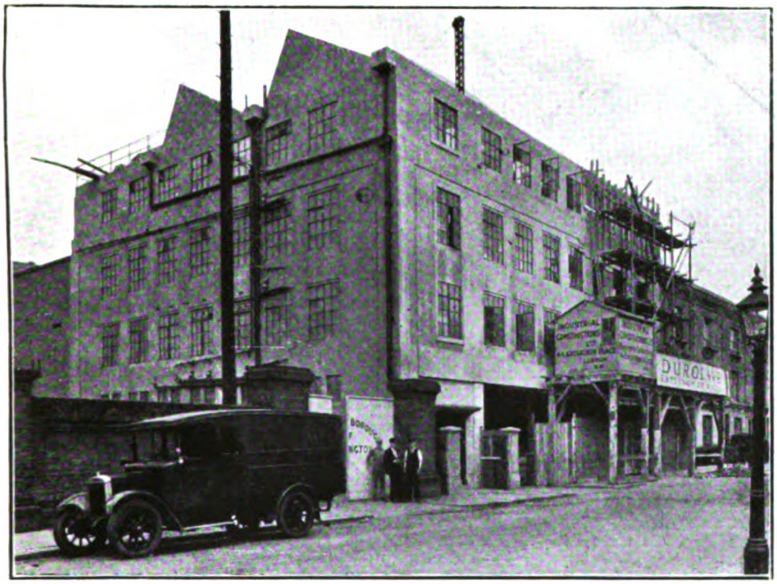

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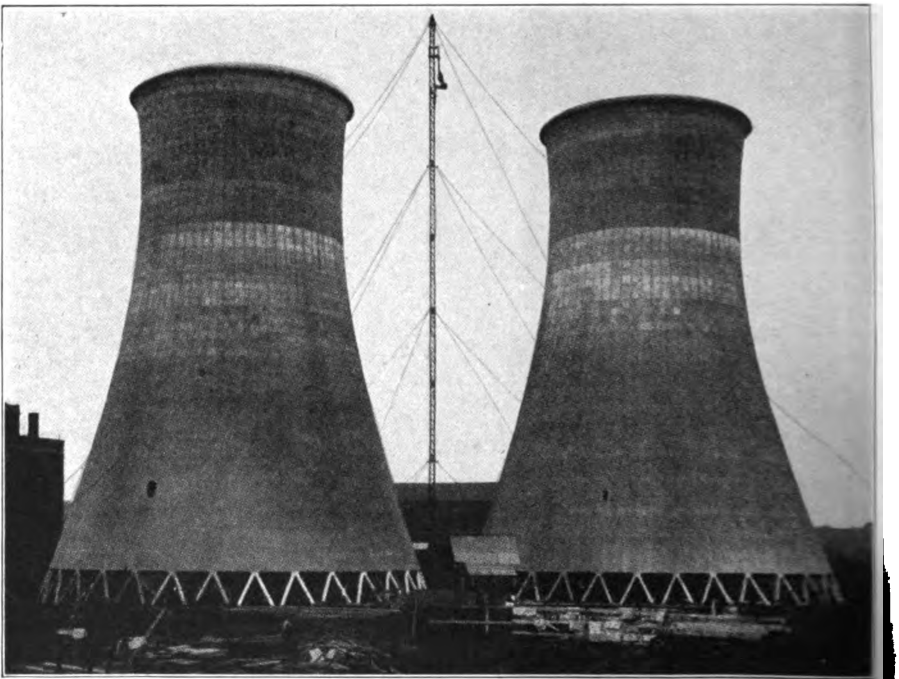

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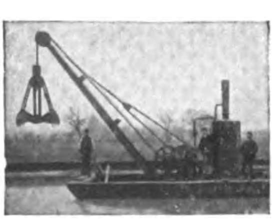

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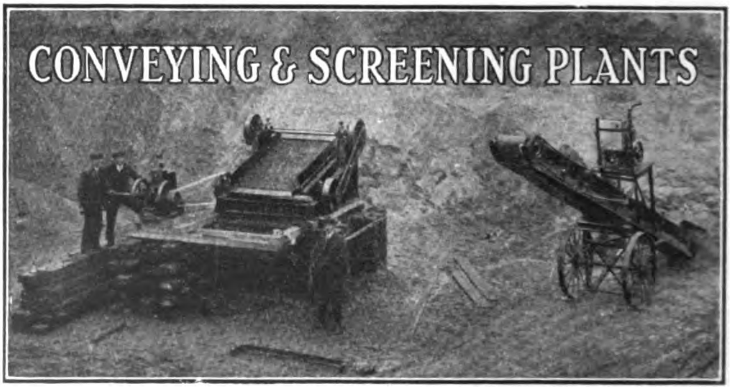

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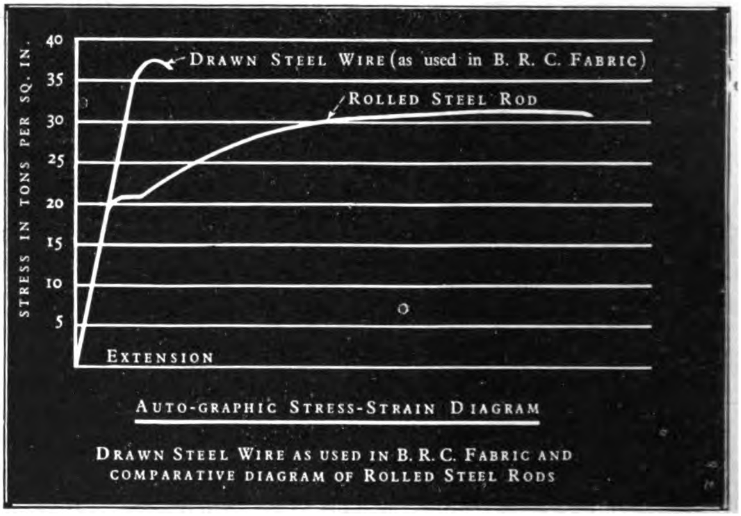

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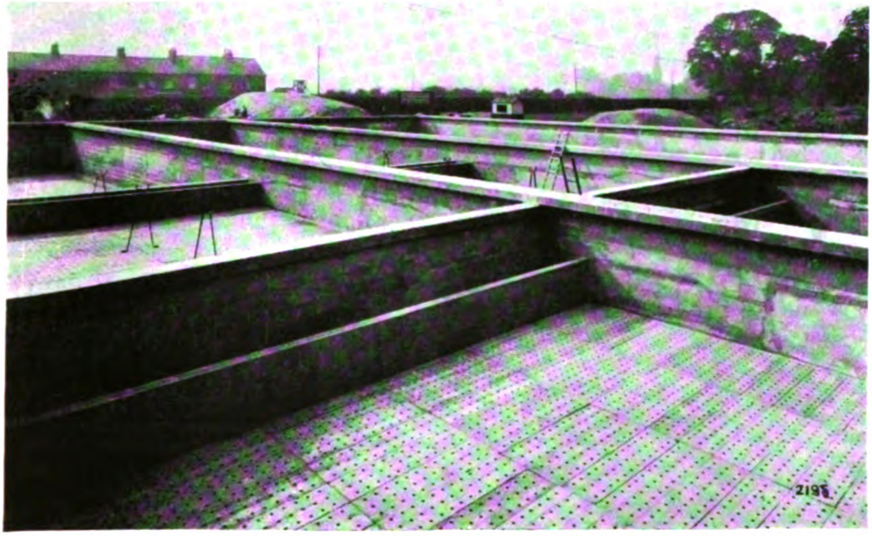

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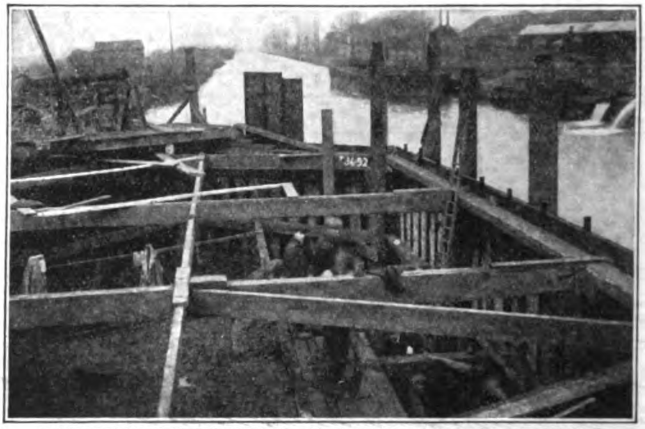

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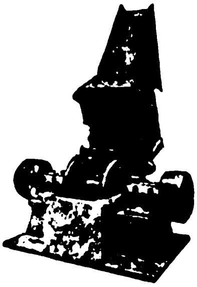

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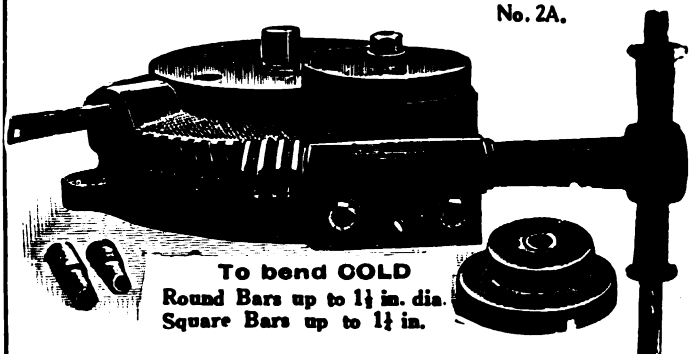

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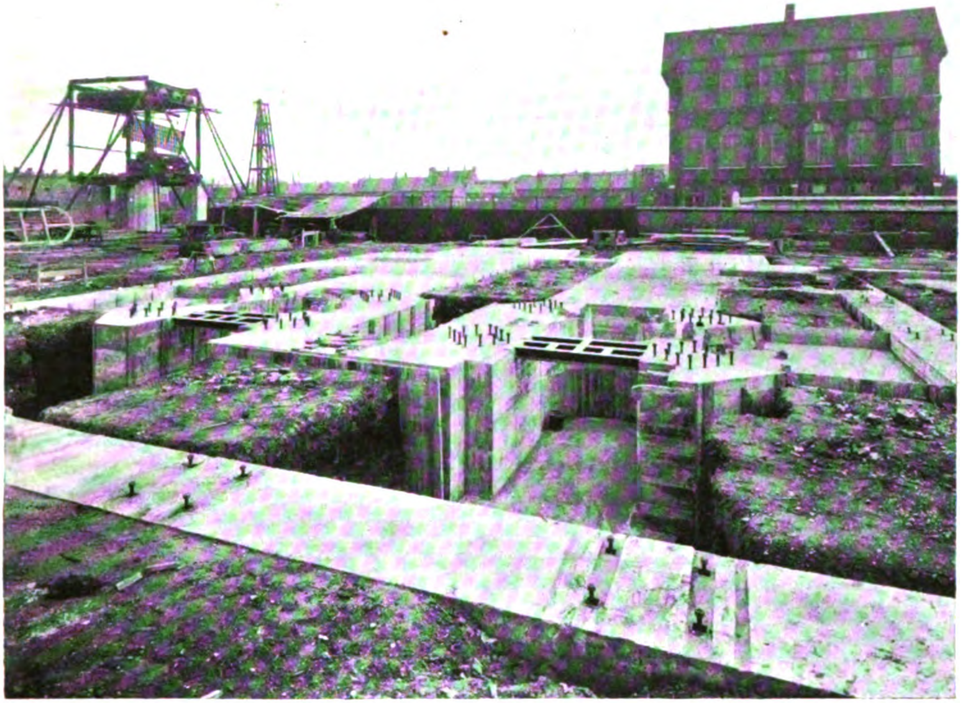

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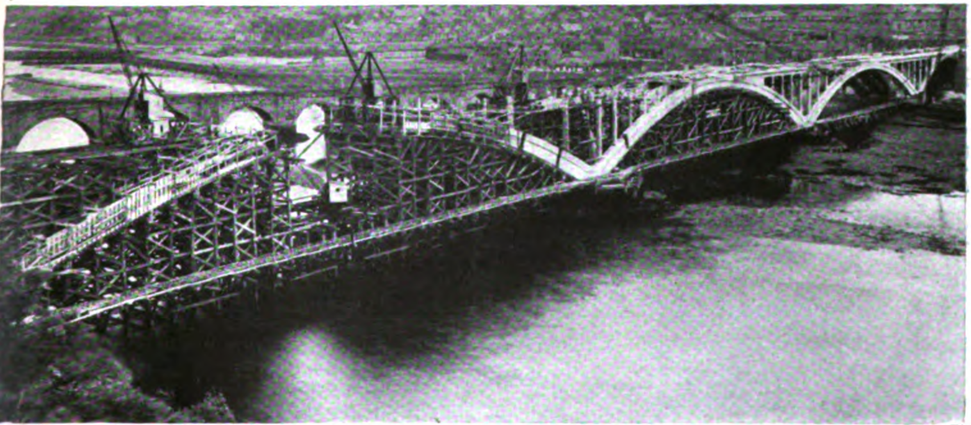

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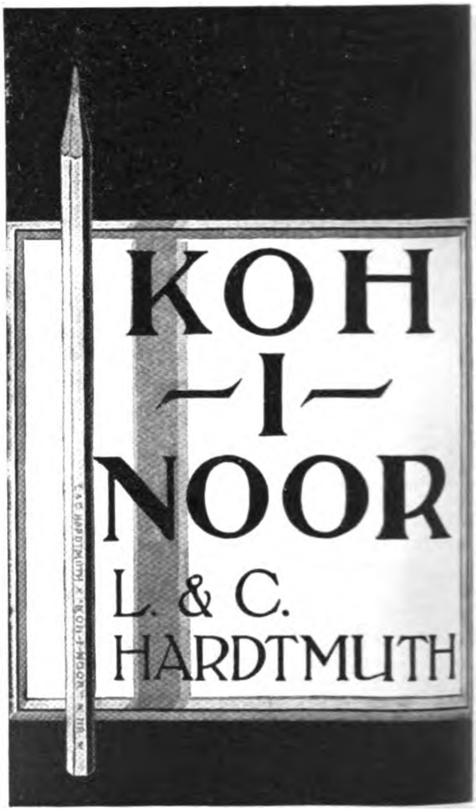

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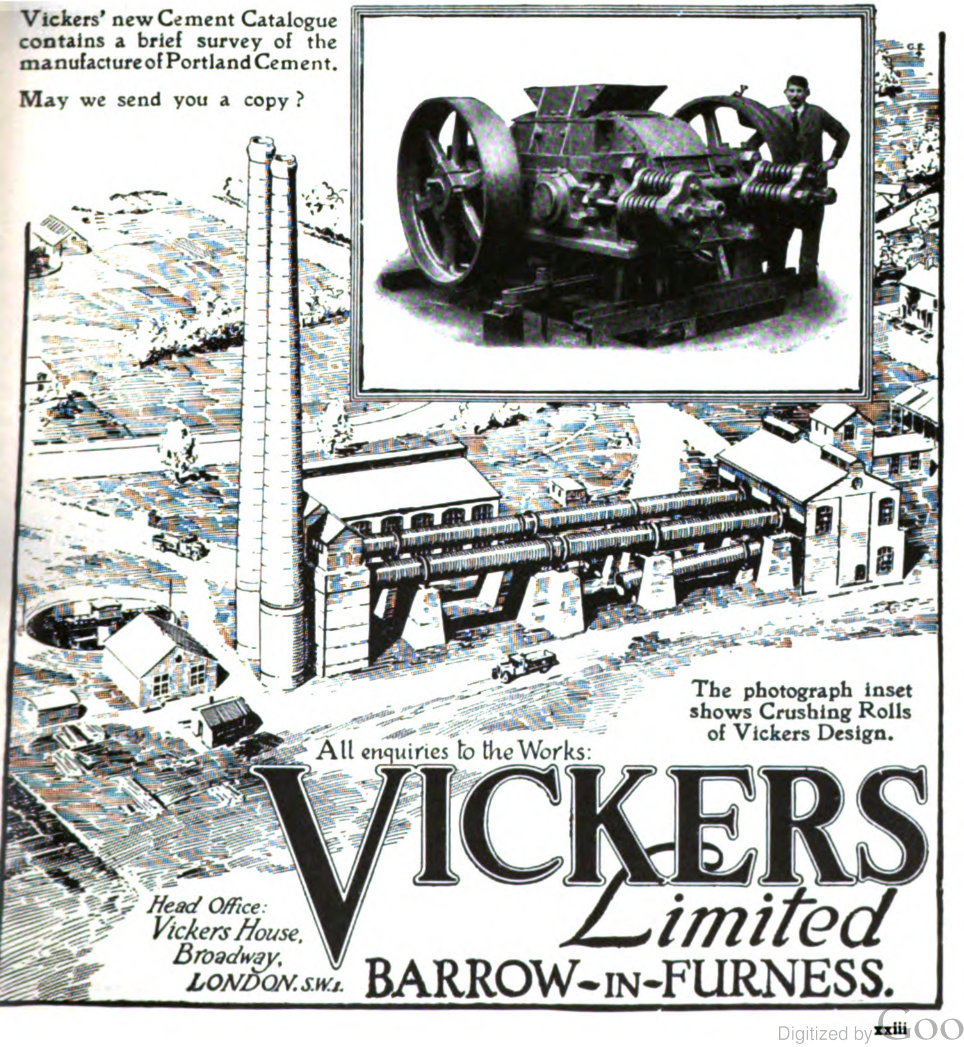

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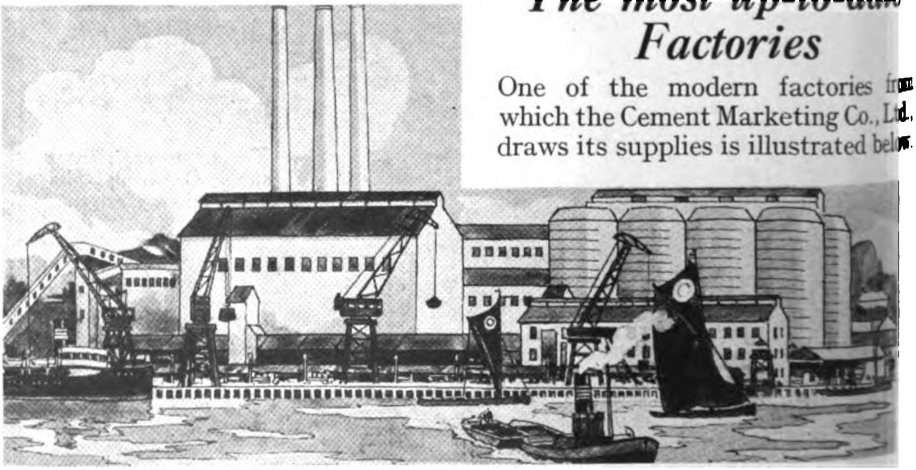

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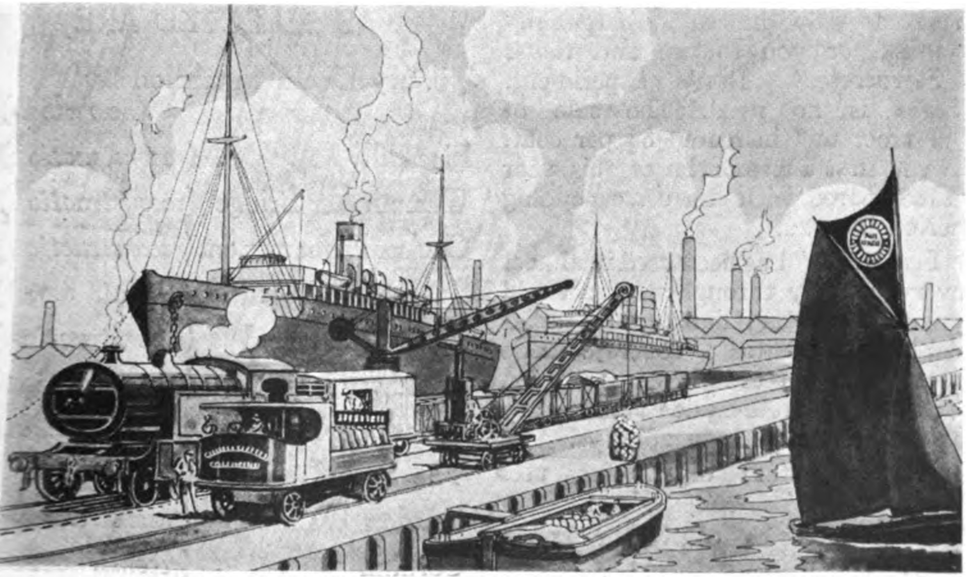

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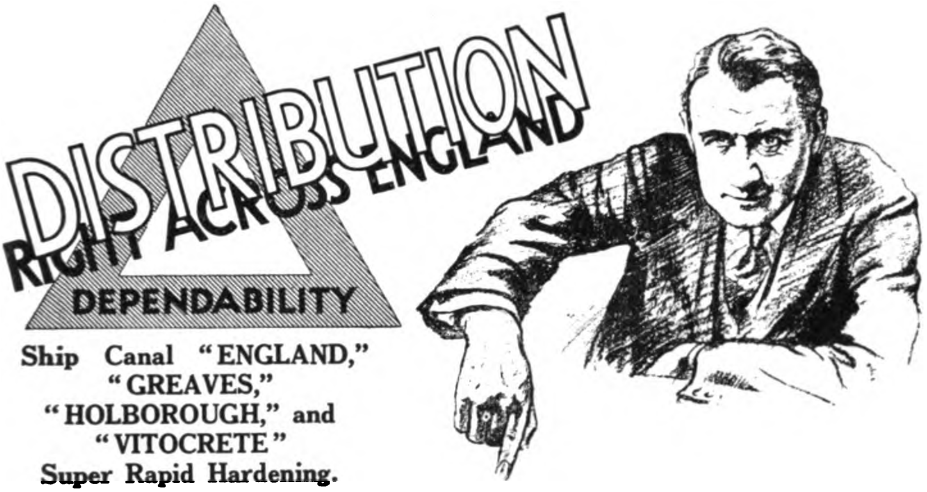

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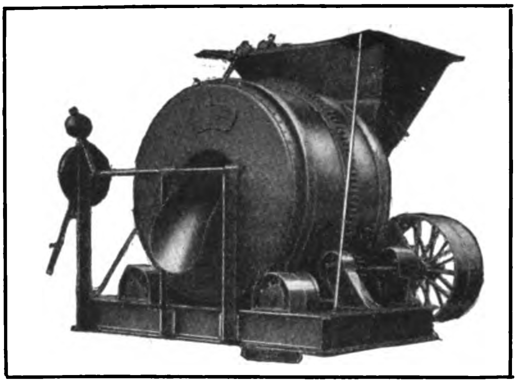

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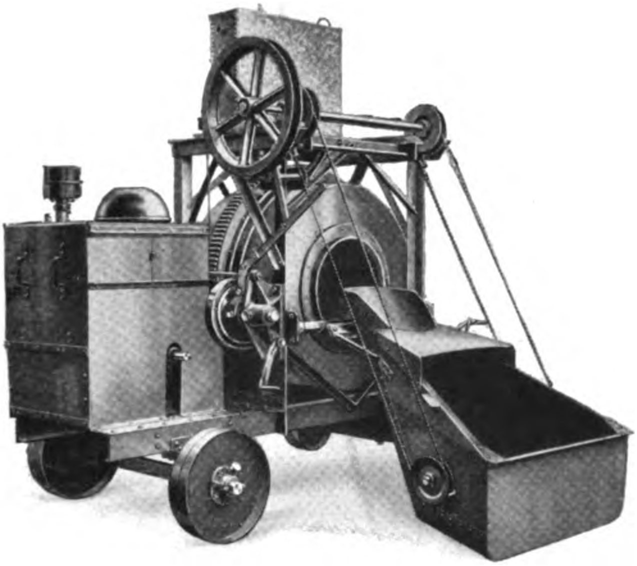

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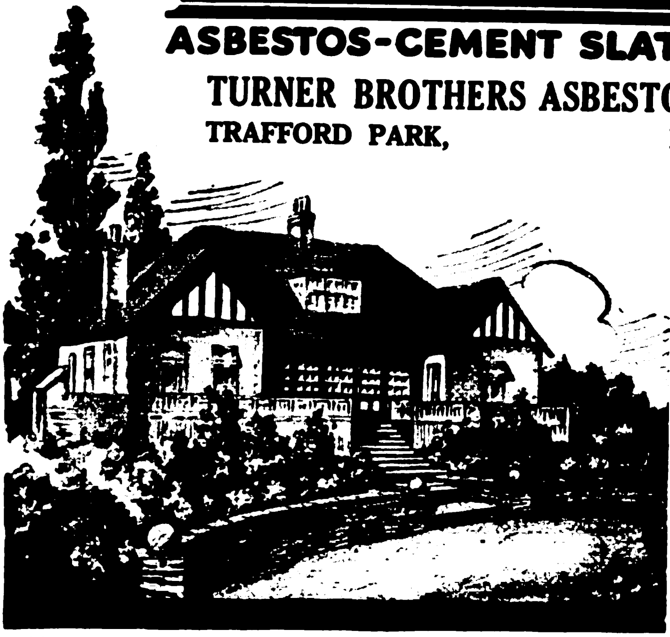

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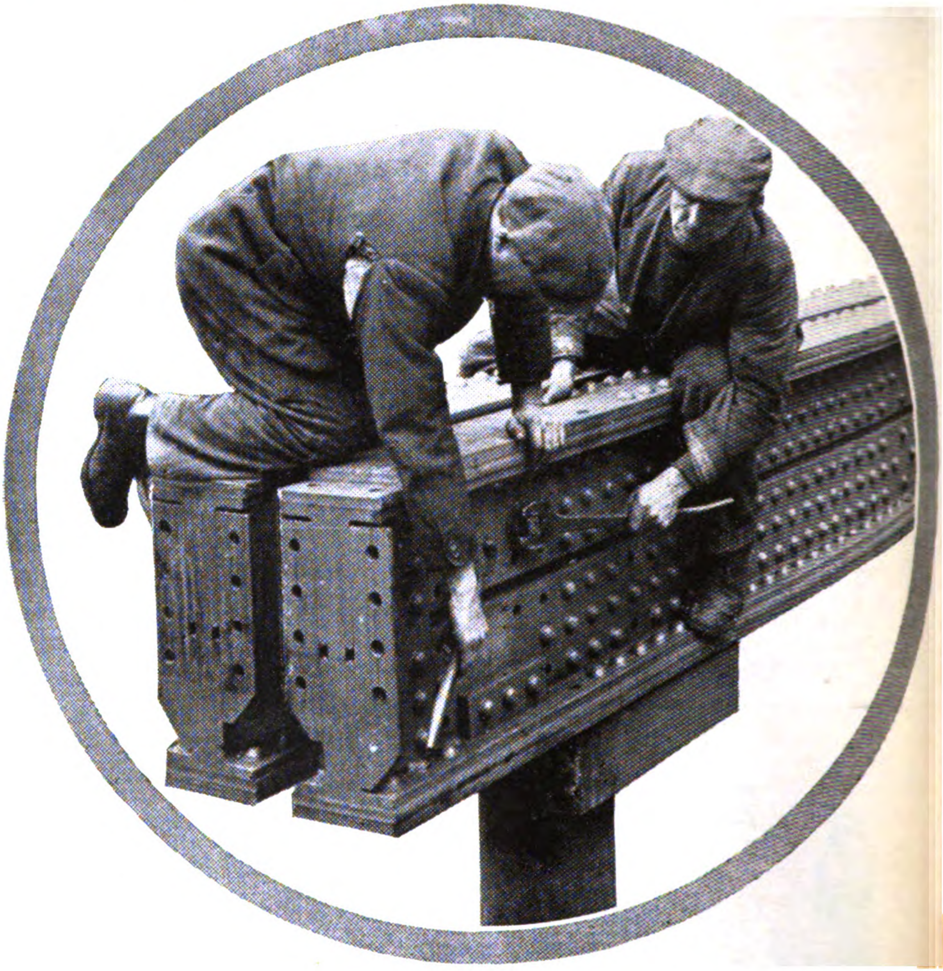

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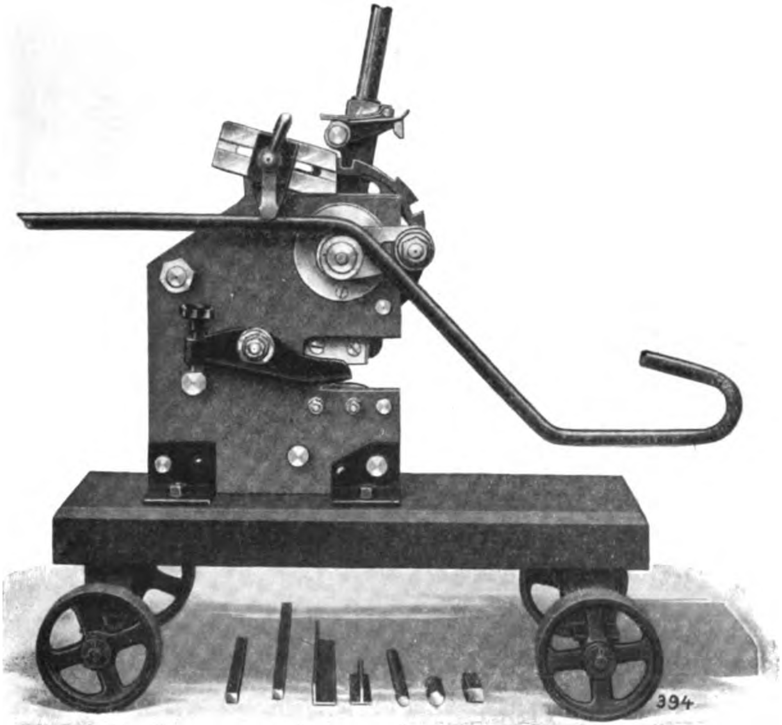

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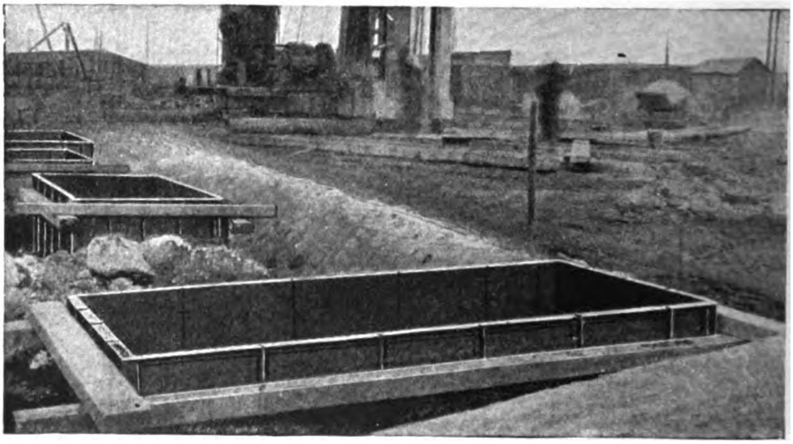

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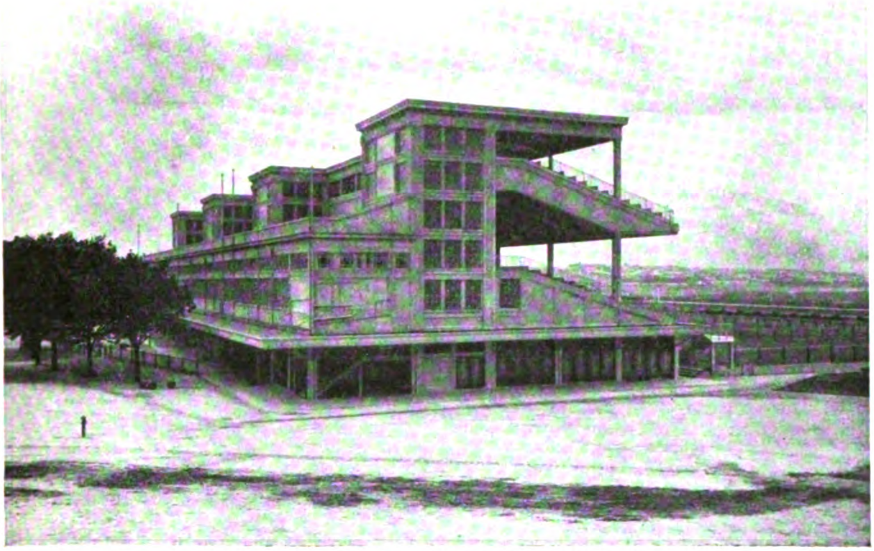

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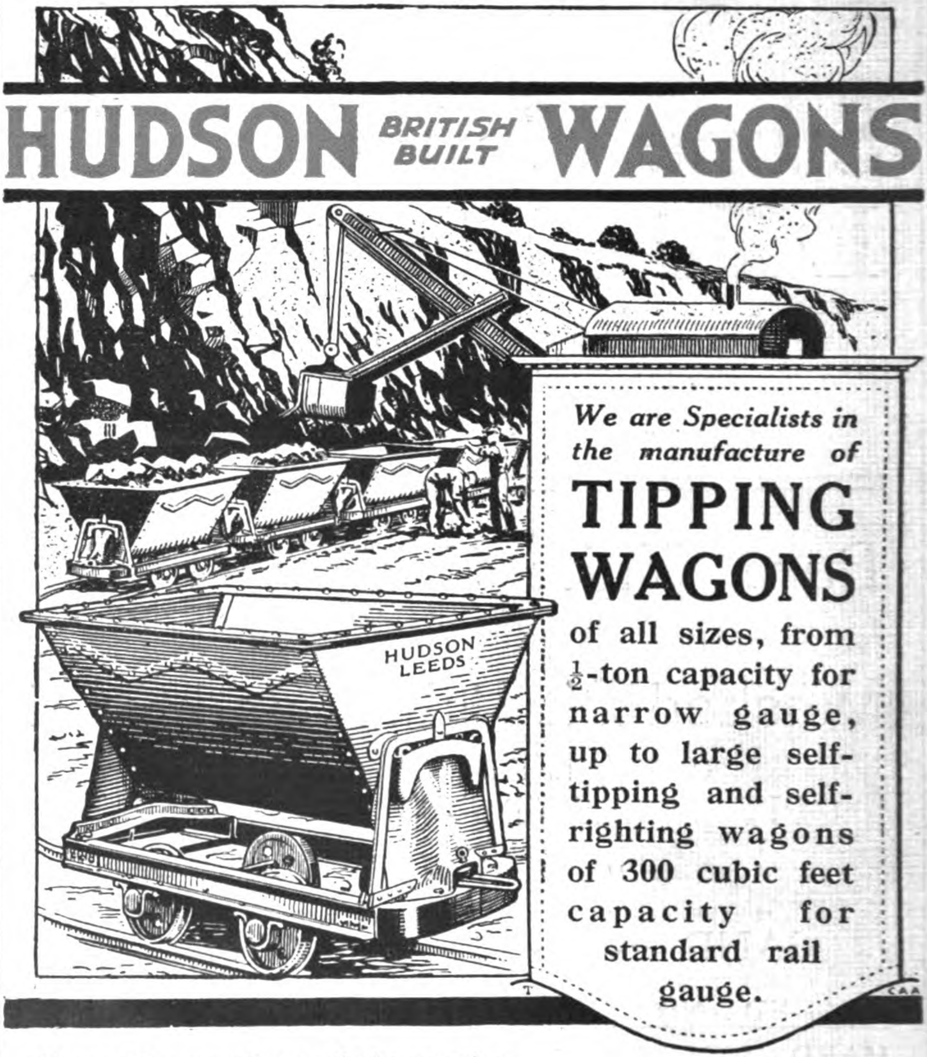

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